JOURNAL

OF THE

Elisha Mitchell Scientific Society

VOL. XXII
1906

PUBLISHED BY THE UNIVERSITY
CHAPEL HILL, N. C.

ky

Journal of the Mitchell Society.

CONTENTS.

VOL. XXII.

1906.

/14

JOURNAL

OF THE

ELISHA MITCHELL SCIENTIFIC SOCIETY.

MARCH, 1906

VOL. XXII NO. 1

"PHYSIOLOGICAL ECONOMY IN NUTRITION"—*Chittenden*.

DR. ISAAC H. MANNING.

There cannot be a more generally interesting subject than Physiological Economy in Nutrition. The habit of excessive indulgence at the table is still very common and habitual over-eating is practically universal. The pernicious effects of the former are often immediate and convincing, while the harmful effects of the latter, though insidious, are none the less certain. The restraint of one's appetite, after generations of hereditary and years of acquired indulgence, and its restriction to a diet nearly approaching the actual needs of the body, requires a degree of self control and watchfulness that few of us possess, and yet it needs no argument to convince us that every ounce in excess of this entails a wasteful expenditure of body energy, an unnecessary and harmful burden on the body machinery, and places both our mental and physical effectiveness on a lower plane. The mental and physical hebetude following a heavy meal is a common experience and so often has disease been traceable to disturbances

Printed March 10th.

in nutrition that it is a medical axiom that the "majority of diseases of mankind are due to or are connected with perversions of nutrition." The habit of undereating is none the less pernicious, but, if we are to accept Dr. Chittenden's standards, it is so rare as to demand little consideration.

A diet just sufficient to maintain the highest mental and physical effectiveness, with due consideration for a capricious, somewhat fanciful appetite is the ideal. An effort to establish such a dietetic minimum, of more or less general application, through experiment, has resulted in the formulation of dietetic standards by Voit, Ranke, Hoppe-Seyler, and others, all agreeing in the main that the average adult doing an ordinary amount of work requires something more than 100 grams (3 to 4 oz.) Proteids (the chief constituent of meat), 250 grams (9–10 oz.) Carbohydrates (the chief constituents of cereals), and 100 grams (3–4 oz.) fat; which, together, should have a heat value of about 3,000 heat units (the large calorie). On such a diet it has been found that the individual could maintain a nutritive balance, neither gaining nor losing in weight. These standards have been generally adopted and an analysis of the average diet of soldiers and laborers of different nationalities, as well as other groups of men, have shown them to be rather more than less. But from time to time individual experience and experiment have suggested that they were too high and should be subjected to a critical review and revision. With this object in view, Dr. Chittenden, of Yale University, began his investigation, the results of which have been published in book form under the well chosen title of Physiological Economy in Nutrition (Stokes & Co., New York).

Among the striking features of the book is the prominence given the proteid constituents of our diets and his conclusions will be disappointing to the average American who is proverbially a heavy meat-eater and to the athlete who often thinks his success depends upon the number of pounds of meat he can consume. The proteids have been recognized as

the basic constituents of all bioplasm (living substance) and for its repair and growth they must form the most important, though not necessarily the most abundant constituent of our diets, for it has been demonstrated over and over again that one cannot maintain a healthy condition without proteids in one form or another. This has been perhaps the strongest argument with the trainer who wishes to encourage the growth of muscles, notwithstanding the easily proved fact that muscular exercise does not increase the use of proteid matter. Dr. Chittenden calls attention to the fact that an excessive proteid diet produces more strain than any other. They are difficult to digest, difficult to assimilate, and the waste is difficult to eliminate, taxing especially the liver and kidneys. Then again, among the innumerable products of proteid digestion, there are formed many more or less poisonous compounds which act deleteriously on the nervous, muscular, and circulatory systems. Hence an excess of proteids is especially to be avoided. The fat and carbohydrates—especially the latter—are ultimately oxidized to CO_2 and H_2O, and the elimination of the excess does not entail so a great hardship. This, however, does not warrant an excessive indulgence.

An ideal diet, then, should contain just sufficient proteid to make good the wear and tear of the body machinery and to provide for a legitimate growth and, in addition, sufficient carbohydrate (especially) and fat to furnish the body energy; a little meat and the rest vegetable matter. The chief object of the research is to determine the minimum amount of proteid necessary to maintain a proteid balance, with an adequate amount of fats and carbohydrates, for it has been shown that, in the absence of the latter, the proteids will be utilized directly for the production of body energy—a misappropriation—and the proteid diet correspondingly high.

The index to the amount of proteid digested in the body is the amount of nitrogen excreted in the urine during a corresponding period of time. To this is added the amount

of undigested nitrogen and the sum should be equal to the total nitrogen taken in with the food. Where such is the case the individual is said to be in nitrogen balance—the intake is equal to the outgo. If, however, the income is less than the outgo, the individual is accumulating nitrogen as proteid or its by-products. In neither case is one in nitrogen balance. It must be remembered, however, that there may be a nitrogen balance on an excessive proteid diet—so elastic is the assimilating and eliminating power of the body. But it would seem that on a minimum proteid diet this method would give us control of the process.

Different individuals—differing in size, weight, habits, and occupation—require a slightly different amount of proteid, and in order to eliminate this personal equation as far as possible and to make the dietetic standard of general application, it was necessary to experiment upon a number of individuals. In this investigation there was a liberal choice. Among those experimented upon we find professional men, teachers, students, athletes, and soldiers (a squad being detailed from the U. S. Army Hospital corps)—representing a variety of individuals engaged more or less actively in mental and physical exercises.

In previous nutrition experiments the period of time covered by the experiment has been too short to warrant safe conclusions. In these, however, the individuals were under experimental observation for periods of six and nine months, which would seem amply sufficient to determine whether the individual can be maintained indefinitely in nutritive balance with full mental and physical vigor on a given diet. In this respect the investigation is superior to those previously reported and warrants a greater degree of confidence in the conclusions.

The plan of the investigation was exceedingly well thought out and faithfully executed. For two weeks previous to the curtailing of the diet, and while the individual was still living on his accustomed diet, daily determinations of the total

nitrogen excreted in the urine were made and its equivalent in proteid recorded. Then there was a gradual withdrawal of the diet—especially the proteid constituents—thus allowing the body to adjust and adapt itself to the change; and this was continued until a nutritive balance (as indicated by a constant body weight and confirmed by balance experiments) was reached. The balance experiments were performed at stated intervals and covered periods of seven days, during which the food was accurately weighed, samples drawn and analyzed, and daily determinations of the nitrogen in the excreta were made and a balance sheet drawn. During the investigation each individual was furnished with a liberal diet list—the composition of the different ingredients being furnished—from which he might select such articles as would gratify his taste, bearing in mind only the general purpose of the experiment. The advantage of this is obvious when we remember that however choice a diet list may be, if it is restricted in variety, it will become distasteful. Systematic records were kept of the body weight, muscular power, and mental vigor, as is customary in gymnasiums and psychological laboratories, to which was added the testimony of the individual as to his general health, physical and mental condition. In some cases periodical blood examinations were made to detect, if possible, any change in its character in consequence of the restricted diet and the results recorded.

The enormous amount of work entailed by such an investigation can only be appreciated by a careful examination of the innumerable tables which contain the results of the quantitative analyses of foods and excretions, blood tests, physical tests, etc., which were systematically made throughout the entire period on each individual. The energy, patience, and perseverance displayed excites one's admiration.

The investigation seems to demonstrate conclusively that Voit's and all previously formulated standards are much too high, especially as regards their proteid constituents. These can be safely reduced 50 or 60 per cent., provided there is an

adequate amount of fats or carbohydrates. The further conclusion seems warranted that it is seldom necessary to increase the heat value of the food beyond 3,000 large calories and in most instances it may be less. This reduction in the diet does not bring us to vegetarianism nor abstinence from meats, but merely to temperance. Nor does it mean the slightest loss in physical or mental vigor or endurance. On the contrary, the records indicate an increase in muscular power and endurance and so far as mental vigor may be tested or judged, this was unimpaired. The improvement in the general health in Dr. Chittenden himself during the nine months in which he was on a restricted diet and among those who independently adopted a similar regime amply justifies the assertion that dietetic temperance conduces not only to one's general health, but must contribute to longevity of life. Nor does it entail any discomfort arising from an unsatisfied appetite after one has become adapted and adjusted to the restriction, and this may, in a measure, be controlled by prolonged chewing of the food, which is a good habit under any circumstances. It may prove interesting to outline Dr. Chittenden's record of himself during the period of experiment, which is not the least interesting one. Previous to the experiment he was living on a diet corresponding approximately to Voit's standard and was eating sufficient proteids to pass about 16 grams N. in his urine per diem. At this time he was 47 years old and weighed about 167 pounds. He gradually reduced his diet until he was passing on an average of only 5.669 grams N. in 24 hours; corresponding to 35.6 grams Proteids—about one-third the amount prescribed by Voit. And while the heat value of his diet fluctuated to some extent, it seldom exceeded 2,000 large calories and was generally below it. In the early weeks he lost slightly in weight reaching 160 pounds, and it then remained constant throughout the experiment. For a time he would eat no breakfast, a light lunch at 1:30 and a heavier dinner at six. This degree of temperance could be reached only after a gradual reduction, but he states that even now

he has no desire to return to his former habits. He succeeded in reducing the Nitrogen in his urine to a greater extent than any one else, but this was probably due to a greater self control, born of his enthusiasm for the investigation. It is interesting to note that Folin in reporting the analysis of the urine of a vegetarian in apparently perfect health as containing a little less than 5 grams Nitrogen, remarks that "no one would be willing to call it normal urine" (the usual interpretation put upon such urine would be an insufficient action of the kidneys).

It is interesting to contrast Dr. Chittenden's record with Stapleton's, a professional athlete and wrestler, who is described as a man of great muscular development and power. At the beginning of the experiment he weighed about 195 pounds, and on his customary diet was excreting an average of 19.7 grams Nitrogen, corresponding to 123 grams metabolized proteids. (Unfortunately the heat value of the diet is not stated, but it was probably large). He succeeded in reducing the Nitrogen excretion to 9 grams in the 24 hours, corresponding to about 57 grams proteids—a reduction of more than one-half—and this on a diet that rarely exceeded 3,000 heat units. In the early weeks, as before, there was a slight reduction in weight until he reached 185 pounds and this remained fairly constant; his total muscular power increased 25 per cent. during the six months, and this, it may be stated, was not due to a change in the character or the amount of exercise. Similar results were recorded of other athletes and the soldiers who were given more or less vigorous gymnasium exercise, and it may be well to call attention again to the conclusion that a heavy meat diet for athletes is unnecessary and irrational.

The results of this classical investigation are of such far reaching importance that they should not only interest the physician, but every one who takes himself seriously and wishes to bring himself to the highest plane of physical and mental effectiveness. The book is thoroughly readable and comprehensible to the average reader.

CORUNDUM AND THE PERIDOTITES OF WESTERN NORTH CAROLINA.

A REVIEW.

JOSEPH HYDE PRATT AND JOSEPH VOLNEY LEWIS.

Under the above title, Volume I of the North Carolina Geological Survey reports has recently appeared. The scope of the work, however, is broader in many ways than this title indicates. It is a volumes of 464 pages and is illustrated by 45 plates and 35 figures in the text. While the report is the result of collaboration, the work has been divided so that, in the main, the mineralogical investigations have been conducted by Dr. Pratt and the petrographical study of associated rocks has been the work of Professor Lewis. The preface states: "To only a limited extent have the authors been able to carry on field work together. The work for the most part has been done at different times, each working independently. Notwithstanding this fact and the somewhat different methods employed, each has been led to essentially the same conclusions in the interpretation of field observations. Especially is this true in regard to the theories of the origin and present relations of both the peridotites and the corundum.

A brief sketch of Geology of the State is given in Chapter I, with a somewhat fuller description of the belt of gneiss, granites and schists, constituting the mountain section of the west, and in which the peridotites and the corundum deposits of the State occur.

Chapter II deals with the peridotites and associated basic magnesian rocks, including four varieties of peridotites, four pyroxenites, four gabbroic rocks, an amphibolite, and three varieties of diorite. These are chiefly well known types, with the exception of the pyroxenite composed of the orthorhombic

pyroxene, enstatite This rock is somewhat commonly found throughout the region and forms many masses of considerable extent The name *enstatolite* is proposed for this type, in conformity with the terms bronzitite and hypersthenite These rocks are discussed in their relations to the belt of similar rocks which extends the whole length of the eastern crystalline belt, from central Alabama through Georgia, South Carolina, North Carolina, Virginia, Maryland, Delaware, Pennsylvania, New Jersey, New York, the New England States, Quebec, and Newfoundland.

Maps are given showing the distribution and relations of these rocks to the crystalline rocks in eastern North America and western North Carolina, besides several detailed maps of various portions of the belt of particular interest The contoured map of western North Carolina is on scale of eight miles to the inch, with the base printed in three colors, after the manner of the maps of the United States Geological Survey. On this the "Conglomerates, quartzites, slates, etc., chiefly 'Ocoee,' correlated with Cambrian by the U. S. Geological Survey," and the "Gneisses, schists, granites, diorites, and other crystalline rocks of pre-Cambian age," are clearly represented by tints, while the numerous dikes of peridotites and related rocks and the occurences of corundum, chromite and asbestos, are shown in bright red

The petrographic descriptions which constitute Chapter III are illustrated by half-tone reproductions of photomicrographs, showing the mineralogic and structural variations and modes of alteration of the rocks described Following the general descriptions of these rocks throughout the Appalachian region, the distribution and petrographic characters are given in considerable detail for western North Carolina

In addition to the numerous facies of primary rocks, secondary types are also described, including those mechanically derived from the primary types, now represented by gneisses, schists and gabbro-diorite, and also a series of hydrous alter-

ation products, including serpentine, steatite, and chloritite (chlorite-rock). The vast majority of occurrences of these basic rocks, while showing more or less alteration, are essentially fresh primary types, especially the pure olivine-rock dunite, which is much the most common. Steatite is pretty widely distributed as an alteration product, but massive serpentine is almost entirely confined to an area extending about 15 miles north and south of the French Broad river. Even in these cases, however, the origin of the serpentine from peridotites of exactly similar character to those found in adjoining regions is very evident.

Chapter IV takes up the modes of alteration and decomposition of the peridotites, and five distinct processes are recognized: 1. Weathering; 2. Serpentinization; 3. Steatitization; 4. Chlorotitization; 5. Amphibolization. The processes of weathering and sepentinization are wellnigh universal, though developed only to a slight extent except in a few localities. Alteration to talc, chlorite and amphibole are much more limited in their manifestations, but have given rise to many important rock masses. The various processes as affecting the peridotites of diverse composition are described minutely.

The long vexed question of the origin of peridotites is taken up in Chapter V. The strong trend of modern thought toward the theory of igneous origin is clearly brought out, and the correctness of this theory is abundantly substantiated by observations in North Carolina. The data presented upon this point are arranged under five heads: 1. Mineralogic characters; 2. Microscopic characters; 3. Gross structures; 4. Modes of occurrence; 5. Relations to the gneisses and schists. This is followed by a discussion of the general petrology of the peridotites and associated rocks in which the conception of genetic unity of the whole series is strongly emphasized.

It is pointed out as a noteworthy fact that many of these rock types are closely associated in almost every occurrence

throughout the crystalline belt of eastern North America. Usually one or another type preponderates in any particular region, but the associations are always essentially the same. Thus the peridotites, particularly dunite, prevail in North Carolina and Quebec, the pyroxenites in Pennsylvania, and the gabbros are very abundant in Delaware and Maryland. In fact the types represented in the various regions are almost identical, and the petrology is closely similar, except in relative abundance of the various types, and in degree of alteration.

In discussing the magnetic relations of the peridotites, anorthosites, amphibolites, etc., two generations of corundum are recognized. The greater part, including all deposits of commercial value, belongs to the first generation, and was formed by the crystallization of the excess of alumni in the original peridotite magma. A very small part, however, occurring in microscopic grains, has been produced by an excess of alumina arising from the corrosion of anorthite by the still molten magnesia magma. This process has produced the sheaths of intermediate minerals which form the *corrosion mantles*, so beautifully developed in some localities, or which, in some cases, entirely replace the anorthite or the olivine, as the case may be, with nest-like aggregates.

Regarding the age of the peridotites, the conclusion of the present writers may be summarized as follows: Sufficient data are not yet available for a satisfactory determination of the age of these rocks, but their intrusion was probably contemporaneous, or practically so, for the whole region from Newfoundland to Alabama. The peridotite belt lies in a region of great disturbance and intense metamorphism. This fact, together with the geological relations to the northward, suggests the hypothesis that the principal period of intrusion was closely associated with the orogenic movements which closed the Lower Silurian (Ordovician) period. The distribution of these rocks may well mark to a great extent the axis

of most intent folding and faulting. The latter Appalachian disturbances, at the close of the Carboniferous, have produced the laminations so often seen in these rocks, and have probably given occasion for later minor intrusions. This hypothesis is not offered as a final answer to the question of age of the peridotites. Much painstaking work yet remains to be done before an entirely satisfactory solution of this problem can be expected.

The chapter closes with a discussion of the relations of the secondary rocks, in which the attempt is made to trace the various laminated and hydrated alteration products back to their original types. Here the question is reaahed, whether the amphibolites, diorites, hornblende-schists and hornblende gneisses may not themselves have been derived from corresponding pyroxenite types, such as are met with in the Maryland and Delaware gabbro areas. The fact is pointed out that undoubted gabbro-diorites do exist in portions of the belt in North Carolina, and hence it is considered probable that many, if not all of these rocks, as well as similar rocks throughout the region, have had a like origin.

After a discussion of the physical and chemical properties of corundum in Chapter VI, is given a description of the various applications of the mineral in the arts, and an outline of the process of manufacture of the several types of corundum and emory wheels on the market.

Chapter VII deals with the modes of occurrence of corundum. In North Carolina the mineral is known in five types of igneous rock, namely, peridotite, pyroxenite, amphibolite, anorthosite, and pegmatite, in six metamorphic rocks, serpentine, gneiss, mica-schist, amphibole-schist, and chlorite-schist. It is also found in gravel deposits of emery whose relations are undetermined. These modes of occurrence are described in detail, and are compared with similar occurrences, when known, in other parts of the world. The deposits which have been of chief commercial importance in North

Carolina have been associated with peridotites, and to a less extent with pyroxenites and amphibolites. The gravel deposits are of considerable interest on account of the corundum gems (ruby) and associated garnet gems (rhodolite) that have been found in some of them.

With the peridotites the corundum occurs chiefly in "peripheral or border veins" striking along the borders of many of the massive outcrops, and in "interior veins" extending from the borders at greater or less distances toward the center of the peridotite masses. In the pyroxenite and certain of the amphibolite occurrences the mode is similar. In other amphibolites the corundum is irregularly distributed in grains and larger plates and nodules through portions of the rock. Certain small pegmatite dikes accompanying and penetrating both the peridotite and amphibolite, are found also to carry corundum. The corundum-bearing serpentine, amphibolites, and chlorite-schists are simply alterations of some of the foregoing types, with more or less dynamic disturbances and re-arrangement of materials. Corundum-bearing belts of the gneisses and mica-schists, which sometimes pass into quartz-schists, have no apparent or probable relation with the peridotites, although occurring in the same region, and in some cases near the outcrops of these rocks.

The chief localities of corundum-bearing peridotite are in Clay, Macon and Jackson counties, in the southwestern corner of the State, and most of the corundum-bearing gneisses, etc., are also found in the same counties. Certain scattered occurrences of corundum in amphibolite dikes and also in the gneisses are found east of the mountains, particularly in Iredell county.

"Other occurrences of corundum in America" extends the list of corundum-bearing igneous rocks to include granite, syenite, nepheline-syenite, plumasite, norite, andesite, and monchiquite, and adds crystalline limestone to the list of metamorphic corundum-bearing rocks. A brief description

of each of these modes of occurrences is given with references to the literature of those that have been previously described. An additional list of "Modes of occurrence of corundum not found in America" adds to the number of corundum-bearing igneous rocks, kyschtmite, tonalate, gabbro, quartz-porphyry, trachyte, and basalt, besides contact-zones and inclusions in igneous rocks. To the metamorphic list are added corundum-schists and porphyroids and graphite. These are followed in turn by brief descriptions, completing the list to date of all known modes occurrence of corundum throughout the world.

The distribution of corundum is described in Chapter VIII. Like the peridotites, this is treated first with reference to the Appalachian belt as a whole, noting the occurrences in Alabama, Georgia, South Carolina, North Carolina, Pennsylvania, New Jersey, Connecticut and Massachusetts. Corundum in the western part of the country includes descriptions of occurrences thus far known in Montana, Colorado and California. This is followed by a description of the North Carolina localities in detail, arranged by counties, beginning in the southwestern corner of the State. The chapter closes with the description of foreign corundum and emery deposits, including those of Canada, India, Turkey, and the Grecian Archipelago.

Chapter IX deals with the alteration of corundum and its associated minerals in great detail. The list of minerals found associated with corundum in North Carolina includes 62 species, each of which is described, with its mode of occurrence, and its relations to the occurrence of corundum. Many have chemical analyses and crystallographic characters also given. "Minerals associated with corundum not found in North Carolina" adds 12 more to this list, from various American and foreign localities.

The difficult question of the origin of corundum is discussed in Chapter X. This is prefaced by an account of the artificial production of corundum, and the origin of corundum in nature

is introduced by a sketch of the various hypotheses that have been proposed during the last quarter of a century. After a discussion of the field relations and the later experiments in the production of artificial corundum, the conclusion is reached that the corundum was held in solution in the molten magma of the peridotite when it was intruded into the country rocks, and that it separated out among the first minerals segregated as the mass began to cool. The conclusion is also reached that the corundum in the quartz-schists and gneisses is the result of metamorphism of sandstones and shales, some of which were rich in alumina, perhaps in the form of bauxite, which, during metamorphism, crystallized out as corundum.

Chapter XI deals with corundum mining and milling. It is introduced by a historical sketch of corundum mining in the East, followed by a sketch of mining in America. "Suggestions to prospectors" and methods of mining and milling as carried out at various plants, conclude the chapter.

Chapter XII discusses the chromite and other economic minerals of the corundum-peridotite belt. Chromite in promising quantities has been found at a number of the peridotite localities in western North Carolina, particularly in Jackson and Yancey counties. Its origin and relations are discussed and the conclusion reached is essentially the same as for the origin of corundum in peridotites. A discussion of the chemical composition of chromite and its uses, and a description of the chromite locolities of the region, with a summary of occurrences in other parts of the world, follow. The distribution and character of asbestos, nickel ores, serpentine, and limonite, minerals which, thus far, are of minor importance in the region, close the chapter.

An appendix, consisting of a bibliography of American peridotites, and corundum and associated minerals, is not complete, perhaps, as regards the whole of North America, but is believed to be practically complete for North Carolina

and the eastern crystalline region in general. There are also many references to foreign literature in foot-notes throughout the work, and the volume is closed with an elaborate index

Copies of this volume may be had by addressing the North Carolina Geological Survey, Chapel Hill, N. C.

NOTES ON THE GEOLOGY OF CURRITUCK BANKS

BY COLLIER COBB

During the past summer (August, 1904) I have made a careful examination of the Currituck Banks from the Virginia line to Kittyhawk Bay and the Kill Devil Hills, studying also the adjoining islands and mainland to the west.

On Knotts Island the Columbia sands form a thin covering from one to three feet in thickness, resting upon clays of Neocene age, not more than ten to twelve feet thick, at several points where I bored with a soil auger. Beneath these clays are the Tertiary shell marls so well known over eastern North Carolina. This shell-rock, as it is called here, occurs at a number of points in Currituck Sound, as I found by sailing pretty well over the entire sound. A somewhat extensive area of this deposit lies near the surface of the water between Church's Island and the Currituck Bank, being about half a mile west of the Whalehead Life Saving Station.

The cruise in the Sound revealed well-marked channels ending against The Banks at the sites of Old Currituck Inlet, New Currituck Inlet, Caffey's Inlet, and the old inlet opposite Colleton Island. The sand-reefs or banks along the North Carolina coast have grown steadily in length from the time of the earliest settlements, until there is now no inlet from Cape Henry to Oregon Inlet. The inlets through the Currituck Banks have been closed up by the steady southward march of the great barchanes or medanos, crescentic sand-dunes, known locally as whaleheads. These dunes are composed of singularly homogeneous blownsands, the horns or cusps of the barchanes pointing to lee-ward, which is almost due South.

Following the ocean side of Currituck Banks, one may often see a distinct terrace marking the line between the Columbia sands and the Neocene clays; on stormy days comminuted Tertiary shells are washed up; and quite frequently after a storm one may pick up water-worn shells of *Cardium*, *Anomia*, and *Exogyra*, of which I brought away a score of specimens. These are distinctly Cretaceous forms. *Ostrea* is unknown among these deposits, but oyster shell heaps of recent date are common on the sound side near the southern end of Currituck.

The facts go to show that The Banks are not of such recent origin as is usually supposed, but are of the same age geologicaly as the adjacent mainland.

On the Atlantic side of this Currituck Bank I found numerous pebbles, some as much as three to four inches in diameter, buried in the upper sands and muds, some well rounded, others sub-angular, and some of these latter even striated. I have collections of exactly similar stones from the beaches of the North Shore of Massachusetts, from Aquidneck Island, and from Martha's Vineyard. There are, however, in my collection from this Currituck beach many fragments of Triassic trap and sandstone, which are not known among the beach pebbles of the other localities.

These pebbles are, almost without exception, unlike any of the stone of the mainland of North Carolina; and both their position and individual characters point to their glacial origin. It is clear that they are the work of the ice sheet of the last glacial period, drifted southward by icebergs which stranded on the Carolina coast. A rather rapid subsidence of the coast is now in progress, the blown sands and the silt, arrested by aquatic vegetation are rapidly filling in the sound side of the Banks, and the water of the Currituck Sound has already become fresh since it has been cut off from direct communication with the sea, the inflowing streams having leached out the salt.

The Great Whaleshead barchane opposite Church's Island

has moved southward three quarters of a mile in twenty years, and the closing up of the sound has been so rapid as to bring about litigation in the courts for the possession of the new made land. The subsidence of the land is so easily seen from beacons and telegraph poles as to be a matter of remark among the least observant of the inhabitants.

Presented October 11, 1904

THE NEW ORLEANS MEETING OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE AND THE AMERICAN CHEMICAL SOCIETY.

BY CHAS H HERTY

One of the prime objects of the American Association for the Advancement of Science is, as formulated in its Constitution, "by periodical and migratory meetings, to promote intercourse between those who are cultivating science in different parts of America." Following this policy the 35th meeting of the Association was held during Convocation week, Dec. 29th, '05–Jan. 4th, '06 at New Orleans, La., this being the first meeting held in that section of the country. The fact that many of the affiliated societies met at the same time at other points reduced largely the attendance at the New Orleans Meeting, but the joint sessions of Section C (chemistry) and the American Chemical Society resulted in a full program and a large attendance of chemists The buildings of Tulane University were placed at the disposal of the Association, the meetings of Section C and the American Chemical Society being held in the chemical laboratory. The sessions of the American Chemical Society were presided over by President F. P. Venable of the University of North Carolina, while Dr. L. P. Kinnicutt of Worcester, Mass officiated in the sessions of Section C.

In his address as retiring president of the American Chemical Society, President Venable presented an interesting historical account of the early days of chemical research in this country, the development of chemical societies and the publication of journals intended primarily for the stimulation of

research among American chemists The address closed with an appeal for more earnest prosecution of research, especially by those connected with educational institutions.

"The Sanitary Value of a Water Analysis" was discussed by Prof. Kinnicutt the presiding officer of Section C. His wide experience in this important field gave added weight and interest to the conclusions he drew and to the standards he recommend.

It is difficult to make selections from the long list of papers presented. Some however were more general in their character than others and aid thus in such a selection

The many sided claims of Agricultural Chemistry upon all branches of Chemistry were ably set forth in a paper by Dr. H. W. Wiley of the U. S. Bureau of Chemistry, while Dr. W. L. Dudley of Vanderbilt University discussed "Laboratory Designing and Construction," a subject in which all were interested and on which each chemist had his own views; but from the paper and the discussion which followed valuable ideas were gained for guidance in future laboratory construction.

Perhaps the most interesting paper, recording the results of careful research in the laboratory, was that on "Recent Experimental Researches on Osmosis" by Prof. Louis Kahlenberg of the University of Wisconsin. This work, to be published immediately, promises to be revolutionary. Prof. Kahlenberg found in ordinary rubber dam, such as used by dentists, a semi-permeable membrane which, unlike those used in former experiments on osmosis was permeable to colloids but impermeable to crystalloids. The accidental discovery of the great change in osmotic pressure on stirring the liquid lying next to the membrane throws great uncertainty on all results recorded hitherto on this subject.

Prof. W, D. Bancroft of Cornell University presented an interesting paper in which was offered a probable explanation of the marked difference in behavior of electrolytes in very dilute and in concentrated solutions.

A number of valuable papers were read by representatives of the U. S. Bureau of Sails. While far from complete it seems reasonable to hope that the work now being conducted by this Bureau will yet throw valuable light upon the whole subject of artificial fertilization of soils.

Hearty endorsement was given both by the American Chemical Society and by Section C to the efforts of the Committee of Manufacturers "in urging the passage of an act through Congress providing for the sale of tax-free alcohol under proper restriction." The inability at present to secure such tax-free alcohol is most largely responsible for the fact that many of our manufacturers of chemical products can not compete successfully with the manufacturers of "Germany, France and England where the laws permit the sale of tax-free alcohol for use in the arts and industries.

This short sketch will not permit of more detailed discussion of the program, but no account of a meeting of chemists would be complete without some word about the excursions which constitute such pleasant additions to the program, affording the members opportunity for inspecting chemical operations on a commercial scale and at the same time easy means for getting into closer personal touch with each other. The chief object of interest at New Orleans was the Sugar Experiment Station at which was exhibited every stage of the sugar industry from the cutting of the cane in the fields to the barrelling of the pure white sugar. The quaint character of the old French Quarter of New Orleans interested all.

THE CEMENT GOLD ORES OF DEADWOOD, BLACK HILLS, SOUTH DAKOTA.

BY JOSEPH HYDE PRATT.

The ore deposits of the Black Hills that are known as the "Cement Gold Ores" or "Fossil Placer" are to a certain extent peculiar to this general section of South Dakota and are in reality old auriferous placer deposits whose constituent sands and pebbles have become tightly cemented together with silica and iron oxide, forming such a hard, compact rock that now as they break the line of fracture is just as apt to pass through the pebbles of the conglomerate as the cementing material. The conglomerates of which the cement gold ores are a part are found over quite an extensive area as the basal portion of the Cambrian strata, but in most of the areas where they have been observed, they are but a few feet in thickness and carry little or no gold. There are two areas, one in the vicinity of Spearfish Canyon and the other in the vicinity of Lead, about 3 miles west of Deadwood, where the conglomerate reaches a thickness of from 20 to 40 feet. It is the latter locality, however, where the conglomerates are auriferous.

These conglomerates in the vicinity of Lead, Lawrence County, designated as the "Deadwood Cement Gold Ores" have been found over an area but a few miles in length and one mile in width which is exposed as isolated areas extending from just south of the city of Lead in a northerly direction across Bobtail Gulch, Sawpit Gulch, through the small town of Central and across Blacktail Gulch, making a total distance of something over 2 miles in this direction. They

are exposed on each side of this line at intervals so that the total width is about one mile. These conglomerates throughout this area vary considerably in thickness and, although they are all auriferous, they vary widely in the value of their gold contents and it is only in a comparatively small portion of this area that they are of economic importance. The most extensive mining has been done on the slopes of the mountains rising on both sides of Blacktail Gulch in what is known as the Whitewood Mining District. These cement gold ores rest unconformably on the old Algonkian schists and slates which are tilted at very steep angles and they have been derived from the destruction and the erosion of the auriferous quartz seams and veins that these schists contained. In the erosion of these schists there has been left a very uneven surface with ridges and shallow depressions that have been subsequently covered with gravels, which have produced the placer deposits. These are lying conformably with the sandstone and quartzite above. These latter rocks are capped by a flow of porphyritic rock in some cases a phonolite, which was the last rock formed and was intruded through the schists, conglomerate and quartzite as dikes, chimneys and laccolites.

The history of these rocks would read something as follows: The old Algonkian schists and slates which contained the auriferous seams and veins of quartz, were subjected to constant erosion during the early Silurian period, yielding sands, gravels, etc., which in time formed the conglomerate, sandstones, imposed thereon, which are a part of the Cambrian. During the formation of the Cambrian rocks the Algonkian rocks of this section were not submerged, although the Algonkian land was slowly subsiding. These gravels or conglomerates have been partially formed by the action of shallow seas, but they are also the result of erosion by streams and rivers, in the same manner as ordinary placer deposits that are now being worked by hydraulic methods were formed. In many cases the old water courses can be

distinctly traced, as they are exposed in mining the conglomerates. These Algonkian rocks were exposed as a rugged island with perhaps the highest point toward Harney Peak to the south, and in this direction the present cement beds have a tendency to become thinner. This whole Algonkian area was finally submerged and when it was raised again above the surface, the overlying rocks were not disturbed or tilted to any considerable extent. Later the schists, conglomerates and sandstones were cut by intrusions of quartz-porphyry and phonolite, partly in the form of dikes and as laccolite or sheet flows, so that at the present time the rocks are capped by the eruptives. These intrusions have metamorphosed. somewhat, the conglomerates and sandstones, partially converting them into quartzite-conglomerate and quartzite. These intrusive flows also penetrated laterally into the rocks forming thin sheets, varying from a few inches to several feet in thickness.

While the different strata of sandstones and conglomerates are lying conformably with each other, the lower stratum of conglomerate is lying unconformobly upon the Algonkian slates and schists.

While all of these cement ores carry gold values to some extent, they are found to be richer in some portions than in others. There are deep channels between rims of the schist which carry the greater amount of gold, and as the conglomerate is mined toward these rims it becomes thinner and thinner with diminishing values. These ancient channels were the natural lines of concentration.

These sedimentary and metamorphosed rocks have a general northerly course and are dipping in the same direction at a very flat angle (about 12 degrees), while the schists are dipping easterly at very steep angles. At the Homestake mine the small amount of cement or conglomerate ore that was encountered was near the summit of the hill in which are the immense open cuts of this mine. The conglomerate at the Homestake was thin, but becomes thicker toward Blacktail Gulch to the north and at the Phoenix and Jupiter mines

it is as much as 40 feet thick and 700 feet below the summit of the ridge. The thickness of these conglomerates rises from a few feet where they are just above some of the rims of the schists to about 40 feet, measured from the lowest point in the channel to Bessie Gulch. It is the few lower feet that are carrying most of the values, and that in direct contact with the schist, which would correspond in an ordenary placer deposit to the gravel resting on bed rock, contains most of the gold. It is therefore essential in mining these cement or conglomerate ores to clean up carefully all the fines and gravel resting on the schist and a few inches of the schist itself. Then again, the better values will be apt to be found in the troughs and depressions of the schist rock and have a tendency to become less and less toward the rims of the troughs or channels. Also any slight protuberance in the schist which may rise even but an inch or two above the general level, will have acted as ripples and thus have retarded the fall of the gold.

There has been some deposition of sulphides carrying gold in these conglomerates after their formation; but the larger portion of the gold is the free gold that was deposited in the original placer deposits.

It is essential in estimating the value of deposits of this character to determine to what distance from the enriched portions or channels and what thickness this material can be mined and milled as a profit. Thus to satisfactorily sample this ore, it must be so opened up that it can be done from and including a portion of the bed rock upwards for a distance of at least 5 feet as this thickness of material must be removed in ordinary mining.

Another possibility in connection with the mining of these cement ores is that of encountering workable deposits of the gold-bearing schist, The general strike of the band of auriferous schist, upon which is located the Homestake mine would indicate that it would pass about ½ mile to the northwest of the main deposits of cement ores; but the strike of the

auriferous schists encountered in the Caledonia mine is N. 15° W. and its extension would pass almost directly under the conglomerate of Blacktail Gulch. In only a few instances have the underlying schists of these cement ore mines been tested, but in a number of cases where this has been done, fair values have been obtained. In testing the schists care must be taken to reach a sufficient depth before sampling so as to be beyond the influence of the gold that may have penetrated into the schist from the placer deposits.

It has been estimated that $1,500,000 has been taken from these conglomerate or cement ores in the early mining; and in the aggregate there is still a larger value in these deposits.

JOURNAL

OF THE

ELISHA MITCHELL SCIENTIFIC SOCIETY

JUNE, 1906

VOL. XXII NO. 2

CHEMICAL RESEARCH IN AMERICA.*

FRANCIS P. VENABLE.

At the last meeting of the American Chemical Society, held in June at Buffalo, the secretary called for reports from various educational institutions as to the investigations then in progress in their laboratories. I was much struck by three things connected with these reports. The large number of institutions reporting, the wide field covered, analytical, inorganic, organic, physical, physiological, technical and the high grade of the work. These reports promise to be one of the most interesting features of future meetings, and the thought how meagre such details would have been a decade or so ago has led me to devote this presidential address to a discussion of the progress in chemical research in America.

It is to be expected that a people, thinly scattered over a vast area of new and unbroken country, confronted with the problems and difficulties of a nation just emerging from its birth throes, would have little time to give to the arts and sciences, and yet the impetus from the wonderful discoveries

*Presidential address delivered at the New Orleans Meeting of the American Chemical Society, December 30, 1905.

Printed June 21st.

of Priestly, Scheele, and Cavendish and the splendid work of Lavoisier, with his revolutionary deductions, crossed the ocean and found its echoes in our wilderness. That Priestly, one of the greatest of these heroes of chemistry, should have been forced to flee from his native land and find refuge on these shores and should have continued his work here for a time brought the great movement nearer home to us. It is a pleasure to note the appreciation of his work shown by the offer of the chair of chemistry in the University of Pennsylvania, the first institution in this country to show an active interest in the development of chemical science, and the first one to have a distinct professor of chemistry in the person of the celebrated Dr. Benjamin Rush, whose appointment dated from 1769.

This interest took active shape in the formation of the earliest known chemical societies. The Chemical Society of Philadelphia was "instituted" in 1792, forty-nine years before the founding of the London Chemical Society, the first one to be established in Europe. Its first president was Dr. James Woodhouse, professor of chemistry in the University of Pennsylvania, and Priestly was one of the members. Probably the most important paper brought before it was one by Robert Hare on the "Discovery of Means by which a Greater Concentration of Heat Might Be Obtained for Chemical Purposes." In this he announced his invention of the oxy-hydrogen blowpipe—called by him the "hydrostatic blowpipe." Hare was then only twenty years of age. Later he became professor of chemistry in the medical school of the University of Pennsylvania and had a distinguished career as an author and chemist.

In 1811 there was founded by "a number of persons desirous of cultivating chemical science and promoting the state of philosophical inquiry" the Columbian Chemical Society of Philadelphia. The patron was Thomas Jefferson, the president was James Cutbush, professor of natural philosophy, chemistry, and mineralogy in St. John's College, and the membership seems to have been drawn from a wide area, as we

find among them Archibald Bruer, professor of mineralogy in Columbia College, New York; Thomas Cooper, afterwards professor of chemistry and president of South Carolina College; Edward Cutbush, professor of chemistry in Columbian University, Washington; de Butts, of the college of Maryland; Jackson, of Athens College, Ohio; MacLean, of Princeton; Silliman, of Yale; Troost, of Nashville, etc.; truly a national society and the first national society with a distinguished roll of foreign members.

The Delaware Chemical and Geological Society was organized in 1821. It was much more local in character and soon died for lack of support.

The papers presented before these societies are largely discussions of the discoveries or views of European chemists or are of a speculative character. Analyses are reported and methods of analysis devised, but synthetical research is lacking. Dr. Bolton, to whom I am indebted for the foregoing facts concerning the early American chemical societies (J. Am. Chem. Soc. xix. 716), suggests various reasons for the absence of research, but it seems to me that there is sufficient explanation in the necessity for devoting thought and strength to the development and building up of a new country and the small incentive to the search after truth for the truth's sake.

During the first quarter of the nineteenth century while European chemists were busied with atomic weight determinations, the testing of the law of multiple proportions, the extension of the list of elements and the multiplication of new compounds, the few American chemists who had access to laboratories were busied with the analysis of minerals and natural waters. It must be borne in mind that at this time there were no public laboratories either in this country or abroad to which students could readily find access. Universities did not provide laboratories for their students. Certain great teachers abroad, as Berzelius and Gay-Lussac had private laboratories but it was extremely difficult for a young worker to secure admission. The available equipment in this country

must have been meagre indeed. Even the illustration of chemical lectures by experiments was a rare thing. Liebig, in his autobiographic fragment, writes of the lectures which he heard in Paris in 1852. "The experiments were a real delight to me, for they spoke to me in a language which I understood and they united with the lectures in giving a definite connection to the mass of shapeless facts which lay mixed up in my head, without order and without arrangement." It was Liebig himself who a few years later at the University of Giessen opened to students the first public laboratory for research in chemistry.

In this country during the second and third quarters of the nineteenth century the American Journal of Science furnished an excellent medium for the publication of scientific papers. Established in 1816 by Benjamin Silliman at Yale University, it stood for fifty years almost alone for the upbuilding of scientific investigation in America and can boast ninety years of great usefulness. Without some such journal there is little encouragement for research. The scientific man finds a keen delight in the search of truth but he also loves to impart his discoveries to others and to win the commendation of those who can understand and appreciate his work and there must be some arena upon which controversies can be fought out and truth winnowed from the chaff. The chemical contributions to the American Journal of Science have dealt largely with the analysis of minerals, meteorites, and waters. This was especially true of the first few decades.

Schiff and Sentini (Annalen 228, 72) mention as the first work in pure chemistry in America the formation of a compound of arsenious acid with potassium iodide. This was described in the year 1830 by J. P. Emmett. He obtained the compound in the form of a white crystalline powder by adding potassium iodide to a very dilute solution of arsenious acid, or potassium arsenite exactly neutralized with acetic acid. Emmett was professor of chemistry in the University of Virginia from its foundations in 1825 to 1842, one of the band of brilliant men

brought over from England by Mr. Jefferson to aid in the upbuilding of his pet institution. With the exception of a few investigations by Robert Hare and the elder Silliman, which pertained rather to analytical, technical and mineralogical subjects, the communication of Emmett belongs to the earliest period of chemistry in North America.

It will scarcely repay us to linger over the years from 1830 to 1860. These were largely barren years. Not that chemical research was altogether lacking, but it was rather a dim and uncertain light beside the shining of such bright, particular stars as Dumas, Thénard, and Marignac in France, Graham in England, Stas in Belgium, and Wöhler, Liebig, and Kekulé in Germany.

One name stands out prominently during this period, conspicuous not merely because of the paucity of the work done by others but because of the sterling character of his own work. This is the name of J. Lawrence Smith. According to the elder Silliman the first piece of elaborate work or research in organic chemistry by an American was done by J. Lawrence Smith in 1842. Smith was a student of Emmett at the University of Virginia and a visit to Liebig's laboratory at Giessen formed the turning point in his life. His first organic research was entitled: "The Composition of Products of Distillation of Spermaceti." In this he first made known the composition of spermaceti and set aside the views of Chevreul.

Smith was later professor of chemistry in the University of Louisiana, then in the University of Virginia, and lastly in the University of Louisville where he furnished his private laboratory and did most of his work. He was an untiring worker and while much of his time was given to analyses of minerals and meteorites he was also a brilliant investigator. In analytical work we find him suggesting the use of potassium chromate for the separation of barium and strontium, and methods for the decomposition of silicates, especially the well known methods for the determination of alkalies. Only

once or twice did he touch again upon organic chemistry, the subject of his first research. He contributed some sixty or seventy papers up to 1870 and his total contributions number one hundred and forty-five.

Besides the work of Lawrence Smith during this period some excellent work was done by Mallet at the University of Alabama, where he was professor of chemistry and chemist to the Geological Survey of Alabama. Here he made the first of that long and brilliant line of investigations upon the atomic weights—the first atomic weight work done in America. Following up the master work of Berzelius upon the constants, Dumas, Marignac and many others in Europe were busily engaged in making new determinations of them with all the accuracy possible from their improved apparatus and new methods. In his scantily furnished laboratory, Mallet, a pupil of Wöhler, gave himself, so far as his many other duties permitted, to this exacting work, completing in 1856 his determination of the atomic weight of lithium from the chloride, and in 1859 the determination from the sulphate.

While not coming strictly under the head of researches it may be mentioned that some interesting speculations as to chemical theories were proposed by Cooke of Harvard and Lea of Philadelphia in the fifties and we have Hinrichs' remarkable deduction of the fundamental principle of the periodic system that the properties of the chemical elements are functions of their atomic weights, drawn from the consideration of their spectra. The synoptical table of Gibbs of Charleston falls just beyond this period, but is interesting to all Americans as so closely paralleling the practically cotemporaneous work of Meyer and evidently independent of it.

In this diagram, prepared for his classes in 1872, he made use of the spiral very much as was done by de Chancourtois, Meyer, and Mendeléeff, anticipating in a measure the work of Spring, Reynolds, and Crookes. Further he anticipated some of the geometrical work of Haughton, observing that no linear equation can be constructed to give more than rude ap-

proximations of the atomic weights, and that to construct curves, two points of inflection, or contrary curvature, must be given. These are the serpentine cubics afterwards worked out by Haughton.

It is not a sufficient explanation of the barrenness of this period to say that laboratories and other facilities were poor. The absence of proper facilities had not proved a bar in the way of some of the greatest chemists of the century. The spirit of investigation was lacking in our colleges and few of the teachers had the necessary training for it. Very few indeed were those who had received an inspiration by coming in contact with the great masters of the science.

A few years after the close of the great civil war American students began flocking in large numbers to the German universities. A great many of them studied chemistry under the masters of the science such as Wöhler, Liebig, Fresenius, Kekulé, and Hoffman. The best laboratories and the most enthusiastic teachers were then to be found in Germany. The marvellous development of organic chemistry offered a most attractive field of research. Very little attention was given to this branch of chemistry in America before 1872 and the facilities for investigations in organic chemistry were very limited. Such work as was done was still chiefly in the line of mineral analyses or simpler investigation among the inorganic salts. The most important work was the determination of atomic weights and Americans may well be proud of their contribution to the knowledge of these constants, which can be worthily compared with those of any other nation. Cooke, Mallet, Clarke, Richards, Morley, Edgar F. Smith and others have been the leaders in this work, to which some of the best laboratories were largely given up during the last quarter of the nineteenth century.

The hundreds of young chemists, trained in the best methods of the Germans and inspired by their contact with vigorous original thinkers, returning home, brought with them an enthusiasm and an impetus which has since placed American

research well to the front. Those who had this training in the first half of the nineteenth century were comparatively few in number but they were practically the only ones who engaged in important investigations. Cooke, Mallet, Lawrence Smith, and Wolcott Gibbs all studied in German laboratories.

Aside from occasional scattered papers by a student here and there the first institution to send out annual reports of researches undertaken in its laboratory was the University of Virginia. These were regularly reported by Mallet in the *London Chemical News* beginning with the year 1862, and have continued for thirty-three years. In 1877 the Johns Hopkins University began its work and scientific research became an essential function of every true University. From that year we may date the building up of the graduate departments of our larger, wealthier institutions and the setting into motion that immense force which is giving America its proper place among the learned nations of the world—a force which has made Germany what it is to-day. Looking back over the work accomplished it seems scarcely possible that this truly great event took place only a little more than twenty-five years ago.

In 1879 this University gave to the growing body of American chemists the first suitable journal for the publication of their researches. It is true the *American Chemist*, published by the Chandlers in New York, had made its appearance in 1871, but it had failed to secure the adherence and support of more than a small body of chemists and had too technical a tendency for general support. It had already passed out of existence two years before the *American Chemical Journal* appeared. From the beginning the distinguished editor of the latter journal, our former president, Ira Remsen, President of Johns Hopkins University, and fully worthy of all honors which he has received, set a high standard and for twenty-six years has maintained its excellence.

It is difficult to overestimate the influence of such a journal

upon the development of research. At first the regular contributions came from a few laboratories only, notably the Johns Hopkins, Yale, Harvard, Pennsylvania, Virginia, and Cincinnati. Speedily the number grew until all parts of the country were represented and the valuable researches published placed the *Journal* on a plane with the best in the old world. It has thus done more to secure recognition for American research than any other one factor.

There was a crying need, however, for a strong well-organized chemical society. The memory of those early Philadelphia societies has faded out. The only common meeting ground for chemists was furnished by the sub-section of chemistry of the American Association for the Advancement of Science which did not rise, however, to the dignity of a section until 1881. It is true that this became one of the largest and most active sections of that association, gathering in annual meetings a hundred or more chemists. It is also true that certain local chemical societies were formed, but a national society was needed on the lines of the English or German or French Societies. The social need for such a society for receiving and entertaining distinguished guests was especially felt during the centennial year and so in 1876 the American Chemical Society was established in New York City. Though it failed to receive hearty support at first and the *Journal* appeared with discouraging irregularity and a woeful paucity of pages, it grew surely and the need for it was increasingly felt. When the happy idea of local sections was evolved many of the difficulties arising from the vast territory covered by the Society disappeared and a rapid growth ensued which has placed us in the fore-front of national societies. The Journal of the Society in 1889 contained 158 pages. In 1904 the total number of pages exceeded 2300, nearly 1700 of these being taken up with original articles. The number of members of the Society is rapidly nearing the 3000 mark.

Besides the *Journal of the Society* and the *American Chemical Journal* other specialized journals have arisen and worthily

represent American research. Among these may be mentioned the *Journal of Physical Chemistry*, the *Transactions of the Electro-Chemical Society*, the *Chemical Engineer* and others. The government scientific departments at Washington have contributed largely to the sum total of American research and a vast amount of investigation in agricultural chemistry has been done in the laboratories of the agricultural colleges and experiment stations established in every state.

Some years ago it was humiliating to see how the work of American chemists was almost completely ignored by foreign investigators and writers. It is a source of pride to-day that we are pressing forward in every branch of pure and applied chemistry and hold a worthy place among those who are adding to the world's store of knowledge and extending the bounds of science. A distinguished European authority has lately testified to the growing strength of American research and the way in which this country is forging to the front. But the fact remains that in these hundred years and more America has produced no great chemist, no Lavoisier to develop a new chemistry, no Wöhler to break down old barriers and add a new realm to the science, no Liebig to revolutionize the agriculture and industries of a world.

In conclusion let me plead for the encouragement of research among American chemists. I sometimes fear that the immense industrial development of the country will call away our strongest and most promising chemists to fields in which the material rewards are greater. And yet for the success of our chemical industries it is imperatively necessary that a large army of quiet workers should be busied in investigation, in the simple search after truth without a dream of the practical utilization of the results obtained. These are the men who patiently and laboriously forge the chain, link by link, that leads to some of the greatest economic changes, often changing the industries of a whole nation. It is chiefly in the laboratories of our colleges and universities that these investigators must be found. There alone can the necessary

freedom of purpose, of view and of action be preserved. There alone is the truth all-important and the money value unconsidered. No truth is insignificant, no fact is too trifling to warrant observation and careful accounting. It was in the laboratory of the University of Giessen that Liebig did his quiet work that made agriculture a science and made possible much of the comfort and luxury of the present day. It was Graebe and his discovery of synthetic alizarin in the laboratory of the University of Berlin which revealed the value of the almost useless coal tar and laid the foundations of Germany's great commercial growth. And many lesser cases might be cited. The governments of Europe vie with one another in fostering chemical research, Germany most wisely doing this in her universities. We as a nation cannot long afford to be behind them in this matter. In the close competition of the near future we must depend upon these toilers of the laboratories for our supremacy in the world's markets. But to my mind a far stronger plea for investigation lies in the inspiration which comes from such work, the broadening horizon and the fuller life.

What are the conditions necessary for chemical research and can we meet these conditions in most or all of our educational institutions? As the spirit of research seems to have developed with the increase in wealth of our larger institutions, many have come to regard research as a prerogative of these institutions and expensive equipment as a prerequisite to it. The idea is totally false and calculated to do much harm. It is accepted by many who hold positions in the smallest colleges as an excuse for their quietly sinking into a dull round of routine and unproductive drudgery. I do not believe that any teacher of science can keep fresh and enthusiastic and have a touch of inspiration about him unless he keeps in touch with nature through personal investigation of her facts and laws. And unless a teacher has these qualities he is not worth his salt and should not have the opportunity for dulling the originality of others. It too often happens that our

young chemists, having completed their researches at some of the larger institutions, published their dissertations, won their doctorates and secured professorships in minor colleges stifle their consciences with the excuse that they lack equipment or leisure, give up all idea of original work, settle down to a humdrum teaching of text-books and limit their ambition to drawing their meagre salaries and grumbling at their poor opportunities.

Let me tell you that which is no secret but is open to every one who has studied the history of the science, neither fine laboratory nor costly outfit nor abundant leisure are essentials for the search after nature's secrets. These are good and helpful things but the one essential is the earnest investigating mind, enthusiastic, determined, and plucky in surmounting obstacles. A quiet corner, a little apparatus, some spare time snatched from a multitude of other duties, these will suffice to give any one the opportunity to show what is in him. If he fails to avail himself of it, it is a tacit confession of his lack of energy, or originality, or pluck. He need not grumble at his meagre salary. He is getting more than he is worth.

I do not mean to be unjust or harsh but when I think of the thousands of young men who year after year are subjected to deadening, uninspiring, humdrum teaching of science and are thus lost to the ranks of our workers, and of the possible brilliant, elect spirits among that number, I must cry out at the terrible waste. The field of knowledge is vast and growing vaster with the ever widening horizon. The harvest is plentiful and the call for laborers is ever more insistent. It is necessary to impress this great truth that the true teacher must be a learner also, drawing constantly fresh inspiration from the fountain head.

THE CORAL SIDERASTREA RADIANS AND ITS POSTLARVAL DEVELOPMENT.*

H. V. WILSON.

The Coral Siderastrea Radians and its Postlarval Development. By J. E. Duerden. Washington, U. S. A. Published by the Carnegie Institution. December, 1904. Pp. 130, with 11 plates.

The handsome Carnegie memoir contains the record of an investigation begun at the Institute of Jamaica and subsequently carried on at the Johns Hopkins University and the American Museum of Natural History in New York. The author's prolonged residence in the West Indies gave him unusual opportunities in the way of command over living material, and the memoir makes valuable additions to our knowledge on many points of coral morphology.

An introduction deals with the systematic zoology and the habits of the species which is abundant and accessible in Kingston harbor. The form is obviously one of those convenient hardy types destined to play a part in laboratory investigations of histological and physiological character. Both the adult colony and the young polyp after metamophosis grow in confinement and may be hand-fed. There follows an ample description of the anatomy of the adult. The species, like other West Indian corals, is possibly protogynous, although Professor Duerden calls to mind that Gardiner has established the converse phenomenon, protandry for *Flabellum*. Duerden takes up the question as to the way in which the coral skeleton, as a product of cellular activity, is

*Reprinted from *Science*, *N. S.*, Vol. XXIII., No. 587, Pages 497–498, March 30, 1906.

produced. He confirms Miss Ogilvie's observation that the corallum can be seen in favorable parts of the adult and young polyps to be composed of minute skeletal units of a polygonal shape and exhibiting a fibro-crystalline structure. But whereas Miss Ogilvie interpreted these bodies as actual cells which were produced through the proliferation of the ectoderm, becoming calcified as fast as produced, Duerden regards them as secretory products which are laid down wholly external to the ectodermal cells. In support of this view, essentially that advanced by von Koch, Duerden finds that the layer of estoderm concerned in the production of the skeleton is always a simple layer, and that, moreover, it is always separated from the corallum by a homogeneous mesoglœa-like stratum. It is in this stratum of homogeneous matrix that the author believes the calcareous crystals forming the skeleton are first deposited.

A third section deals with the post-larval development. The larvæ, of the usual coral type, were obtained in July, and were kept under continuous observation for some months after attachment. Many valuable facts concerning the succession of the tentacles, mesenteries and various parts of the corallum are recorded in this section. A feature of interest lies in the attention paid to individual polyps. The partial transparency of the young animal permits of instructive views during life, and thus in one and the same individual the correlated development of the various organs could be followed from day to day. A result of this method was that periods of rapid growth and relative rest could be distinguished. The author points out that a phylogenetic significance possibly attaches to some of the more persistent stages, such as, for instance, that in which complete pairs of mesenteries (directives) are found at the two ends of the œsophagus, with two pairs, each consisting of a long (complete) mesentery and a short one. on each side of the œsophagus. This condition continued unchanged for a period varying from three weeks to three months. The author's theoretical views as to

the meaning of this particular stage are summed up as follows:

> The long retention of freedom of the fifth and sixth pairs of protocnemes suggests to my mind an ancestry in which the mesenteries as a whole, including the metacnemes, were alternately long and short, excluding, of course, the axial directives. Among modern examples this is retained in the menesterial system of the zoanthids, *Porites*, and *Madrepora*, and was perhaps characteristic of the Rugosa.

The building up of the corallum is followed out in detail through the formation of the third cycle of permanent septa. Among the illustrations of this part of the work special mention is due the microphotographs of macerated skeletons of developing polyps, and the figures of living polyps with the beginning skeleton *in situ*. Much interest attaches to Professor Duerden's account of the development of the septa. It has been hitherto assumed that the septa of a new cycle appear in the exocœles (*i. e.*, the space between two pairs of mesenteries), but are later embraced by the newly appearing pairs of mesenteries in such wise as to lie in the entocœles(*i. e.*, the space between the mesenteries of a pair). Thus the same septa would be first exocœlic and then entocœlic. In opposition to this scheme Duerden's observations lead him to the conclsion that while exosepta are formed in successive cycles, they never become entosepta. The cycles of entosepta are strictly new formations, appearing as do the primary six septa in entocœlic spaces. The succession of the cycles of exocœlic septa is maintained through the continued peripheral bifurcation of preexisting exocœlic septa. The bifurcated extremities become the (exocœlic) septa of a new cycle, while the main septum is incorporated in the growing body of one of the last formed cycle of entosepta. Having respect only to the actual facts as observed in *Siderastrea*, it has been found that any one of the permanent septa, later than the first six, has a double origin. It is in part a new formation (entocœlic), and in part a preexisting formation (exocœlic). The two parts fuse, and the fusion is interpreted by Professor

Duerden as the incorporation by a growing organ of the remnant of a vanishing organ. In a developing corallum according to this view exosepta are formed at each stage of growth, only to disappear as the permanent septa, entosepta, come into existence. Thus the development of coral septa affords an excellent example of substitution: temporary organs precede and are replaced by permanent organs performing the same function as the former. As a corollary to this conclusion the author expresses his belief that the exoseptal predecessors of the permanent septa do not wholly disappear in all corals, as independent structures, but persist in some species in the shape of the *pali* found in front of the larger septa.

THE SOURCE OF THE SUN'S HEAT.*

JOHN F. LANNEAU.

Doubtless the sun is now receiving more expert attention than any other single object in the material universe.

The world's telescopes daily confront it. At the Solar Observatory in Washington it is questioned almost hourly by Langley's exquisitely sensitive bolometer—sensitive to the one-millionth part of a centigrade degree. At Williams Bay, with the Yerkes' forty-inch telescope and Hale's marvelous spectroheliograph, its entire disk is photographed day by day, giving a permanent record of changes in the spots and faculae of the photosphere, and of the slow or rapid mutations in both the quiescent and the eruptive prominences of the chromosphere. And on Mt. Wilson near Los Angeles, California, is a veritable Sunbeam Laboratory—the unique Solar Observatory of the Carnegie Institute. It is a long, low, multiple-walled, canvas structure. At one end a great clock-controlled heliostat steadily reflects sunbeams horizontally to the far end mirror which returns them to its distant focus, forming there an exceptionally large, well defined image of the sun. This faithful image can be patiently scrutinized the day long, and its every detail permanently mapped by a five-foot spectroheliograph—the largest yet constructed.

ESTABLISHED FACTS.

Since Galileo's embryo telescope, three centuries of persistent effort have built a secure scaffolding for intelligent approach to the distant sun—a scaffolding of established facts.

*Address before the N. C. Academy of Science, May 18, 1906, by President John F. Lanneau.

1. The sun's parallax is now known to within two-hundredths of a second, its apparent diameter to within two seconds. These measurements show that its diameter is 109½ times the earth's diameter; and that its distance from us is not quite ninety-three million miles.

2. Since the volumes of globes compare as the cubes of their diameters, the sun is more than a million times larger than this earth. In mass or weight, however, it is only 332,000 times greater. Its density, therefore, is only one-fourth of the earth's—or not quite one and a half times the density of water.

3. Gravity at the surface of a globe depends on its mass divided by the square of its radius. At the sun's surface therefore, gravity is nearly 28 times greater than gravity at the earth's surface.

That is, if a common brick here weighs 7 pounds, on the sun it would weigh 200 pounds. A brick there would weigh as much as a barrel of flour here!

LOOK AGAIN AT THESE FACTS.

The sun's size:—a vast globe more than three-fourths of a million miles in diameter. From its centre to its surface is nearly twice the distance from the earth to the moon!

The sun's mass:—its immense volume, as shown later, is a seething body of commingling gases—a great globe of glowing gas!

Expanding gas, growing larger and larger? Not at all. The expansive force lessens as the surface temperature is lowered by the cold of outer space; and it is checked also by the continuous inward pull of gravity. At a certain distance from the center, therefore, the outward and inward forces just counterbalance, giving definite size and boundary to the vast solar globe of gas.

"Light as gas?" Yes. But increase quantity, and weight increases. Double, treble, multiply quantity; and weight is

doubled, trebled, multiplied. The sun-globe of gas weighs as much as a third of a million worlds like ours!

The sun's distance:—ninety-three million miles. Our best modern rifled artillery will throw a ball a half mile in one second.

At that rate a cannon ball will go 30 miles a minute; in an hour, 1800 miles; in a day, over 40,000 miles; in a month, more than one and a quarter million miles. And keeping an undeviating course sun-ward with unslacked speed, the so swift cannon ball would not quite reach the sun in six years!

At that unthinkable remoteness, we yet feel here its panting July heat. There, yonder—beyond the swift missile's six year flight—at the sun, on its hot surface, how hot?

NATURE OF HEAT.

Facts in regard to the sun's heat have been reached slowly because of peculiar difficulties due to the nature of heat. It is not, as once held, the fourth form of elementary matter—earth, water, air, fire—nor yet, the subtile matter, "caloric", of a century ago.

Indeed, though intimately associated with all forms of matter, heat itself is not matter. It is force—energy—the force or energy of the constituent particles of either solids, liquids, or gases when the particles are in rapid motion—in minute, invisible, intense vibration.

Matter may be opaque or transparent. We perceive its heat by the sense of touch. Heat is recognized not visually, but palpably. It is felt.

As the feeling of warmth is the effect of the intense, invisible activity of the constituent particles of matter, so that of coldness results from their inactivity—their stillness.

Every hot body tends to coldness because its hedged-in multitudes of agitated particles, by the resistance of their recurring collisions, gradually settle towards rest.

Meanwhile, the molecular vibrations, imparted to the adjacent all prevading ether, are transmitted radially to distant

bodies, communicating vibratory motion to their particles. Thus a cold body may receive radiated heat from a distant hot body.

Air waves bring us the musical vibrations of a distant bell, and its pleasing sounds are reproduced in our aural nerves. Ether waves bring us the vibrations of a distant hot body, and its heat is reproduced in our tactile nerves.

Usually heat is produced in either of two ways, mechanically or chemically.

The heat of combustion in a wood or coal fire, or in a candle, is produced by the avidity of the oxygen particles of the air for the constituent particles of the fuel. Their clashings in chemical union maintain that atomic commotion which constitutes the heat of the fire or of the candle flame—heat produced chemically.

Hammer vigorously a cold anvil. Both anvil and hammer become hot. The checked energy of the descending hammer is reproduced in the invisible commotion of the iron's particles. Energy of mass is transformed into energy of molecules, into heat—heat produced mechanically.

Force, like matter, is indestructible. This is the gist of the broad physical law of the conservation of energy. If any force is seemingly annulled, Proteus-like it reappears in a new form—or, it is stored for future delivery.

The mechanical power of Niagara's water becomes in the shafts crowning dynamo electric power. And that electric power at Niagara becomes in distant Buffalo light energy, or heat energy, or again motive power.

From yonder far off, hot sun comes radiated heat; from this, our tropic and temperate heat, our wind and water power, and plant and animal energy; indeed, all terrestrial activity—from the modest up-peep of tiniest grass-blade, to the proud coursing high over continents and seas of the coming air-ship!

AMOUNT OF SUN'S HEAT.

The elder Herschel was the first to investigate the universe

of stars and nebulae. His illustrous son in 1838 took the first well directed step in the study of the sun's heat.

A sunbeam of a known section, imparting its heat to a definite weight of water, raising its temperature an observed number of degrees, in a certain length of time, gave the coveted, fundamental data.

Namely, the amount of heat received on a square foot of surface in one minute—taking as a unit of heat, the heat which raises a pound of water one degree Fahrenheit.

He found that the heat received at the earth from the sun in the zenith, is sufficient to melt an inch-thick layer of ice in 2 hours and 13 minutes.

That is, if an inch-thick shell of ice encompassed the sun, distant from its centre in all directions 93 million miles, that immense, remote ice shell would all be melted in 2 hours and 13 minutes.

With Young, our highest authority on solar facts, fancy such an inch-thick shell of ice kept intact and drawn inward toward the sun, all the while containing the same quantity of ice, becoming thicker as it lessens in size. When it touches the sun's surface, its thickness will exceed one mile.

That vast, solid glacier embracing the sun, at every point over one mile high, would all be melted by the the sun's heat in 2 hours and 13 minutes. It would melt a layer about 40 feet thick each minute !

All honor to Herschel's conception and achievement. His method was perfect, but not his instruments. Better means now prove that the sun radiates from its entire surface in one minute enough heat to melt encasing ice 64 feet thick !

TEMPERATURE OF THE SUN.

Within experimental limits Stephan's thermal law holds; namely, that the rate of heat radiation is as the fourth power of the absolute temperature. Assuming it to hold universally, this law and the known rate of sun's radiation—500,000 units of heat per minute from each square foot of solar sur-

face—give as the sun's surface temperature 12000° F.; about sixty times the temperature of boiling water!

With much more certainty a lower limit to the sun's surface temperature has been found experimentally.

Scheiner by ingenious use of the spectroscope, comparing lines of the solar spectrum with certain lines of magnesium, proved that the photosphere is hotter than the electric arc—that is, that its temperature is certainly above 7000° F.

So also, the heat at the focus of a powerful lens has furnished a lower limit in a very realistic way.

The sun's rays received on a lens or burning-glass are converged to its focus, producing at that point a high temperature. A point out in space to which the sun's rays naturally converge at an angle equal to the focusing angle of the lens, may be termed the space-point of equal temperature. Its distance from the sun is easily found. For the ratio of that distance to the focal length of the lens, is the known ratio of the sun's diameter to the lens' diameter.

At the focus of the largest lens yet constructed the high temperature produced instantly melted and vaporized the most refractory materials—platinum, fire-clay, carbon—everything tested.

And its space-point of equal temperature is about 250,000 miles from the sun's surface—a little further from the sun than the moon is from us.

If then our solid earth were placed at that distance from the sun—a quarter of a million miles—it would quickly melt—vaporize—vanish!

That certainly is the temperature at one-fourth of a million miles from the sun. Still higher is it at the sun's surface—and inconceivably higher, the internal temperature.

SOURCE OF THE HEAT.

How does the sun produce its enormous output of heat, and maintain its inconceivably high temperature?

Of four theories to be considered—if the newest suggestion can be called a theory—only one is perfectly satisfactory.

1. THE COOLING THEORY.

It is certain that the sun is not simply an intensely hot body slowly cooling. For in that case, its materially lowered temperature after thousands of years of human history would have caused decided climatic changes. But we know the vine, the olive and the palm are fruitful now just where they flourished in the days of classic writers.

2. THE COMBUSTION THEORY.

It is equally certain that the sun is not simply burning up—that its heat does not result from ordinary combustion.

As estimated by Young, its continuous great yield of heat could be produced by the consumption every hour of a layer of coal all over the sun's surface nineteen feet deep. That is, by burning one ton of coal hourly on each square foot of the sun's surface.

Lord Kelvin computes that were its vast mass solid coal environed by pure oxygen, and yielding its heat by combustion, it would be utterly consumed in five thousand years. It would, then, have dwindled more than one-third since Ptolemy's day. Yet, in the nearly two thousand years elapsed, it has certainly not diminished appreciably.

3. THE RADIUM THEORY.

Though not produced by combustion, the sun's heat is now surmised by some to be due largely if not entirely to radium—that most remarkable of known substances, discovered less than eight years ago by Mme. Curie.

Proofs of its properties are ably presented in Rutherford's "Radio-Activity". It is not only self-luminous, but is also self-heating, giving out every hour enough heat to melt more than its own weight—of ice—a fourth more.

It seems to be a very rare element. Tons of pitchblende yield only a few grains of radium.

But as radium evolves helium, and helium is known to be a chief component of the sun's chromosphere, it is suggested that the sun contains much radium.

Recall that the sun radiates from its entire surface in one minute enough heat to melt encasing ice 64 feet thick. With this measure of the sun's heat, and radium's heat emission per minute—melting one forty-eighth of its own weight of ice—as data, we readily find that the sun's heat equals the heat emitted by a mass of pure radium weighing nearly as much as the whole earth weighs. That much of this rare and peculiar element in the sun—our world's weight of radium—would yield its known output of heat.

The surmize that such a quantity of radium is there, rather segregates the sun from common matter.

Moreover, the properties of radium are none too well known.

At present, therefore, attributing the sun's heat to radium, is simply an interesting speculation.

4. THE MECHANICAL THEORY.

There remains for consideration the mechanical origin of solar heat—that is, the conversion of force, or the energy of moving matter, into heat energy.

There can be no doubt that many millions of meteoric bodies are hourly falling into the sun. We know that something like twenty million so-called shooting stars plunge into our atmosphere daily. Their checked energy of motion reappears in the air as light and heat.

But the heat thus imparted to our earth in a year has been shown to be less than we receive from the sun in one second!

Incomparably more of these meteoric bodies must plunge into the solar atmosphere contributing, however, comparatively little to the sun's heat. For while interplanetary space, at least as far out as the earth's orbit, is threaded by

countless meteoroids, if sufficiently numerous to produce by impact on the sun a large part of its heat, the outlying multitudes would affect perceptibly not only the periodic comets but also the planet Mercury. And no such effects have developed.

Helmholtz's theory of the mechanical origin of solar heat —his contraction theory announced in 1853—fully accounts for the sun's heat.

Recall that the inward pull of gravity at the sun's surface is nearly twenty-eight times gravity at the earth's surface. Abundant evidence furnished by the spectroscope, and the sun's known low density—not much greater than that of water—force the conclusion that the sun is a vast sphere of commingling gases, including the vapor of most, if not all, of the terrestrial elements.

As the sun contracts by its own powerful gravitation, the potential energy lost by gradual inward motion is replaced by equivalent heat energy. Every particle in the whole stupendous mass moving inward, contributes to the sun's inconceivable aggregate of heat. Helmholtz computed that an annual contraction of 200 feet in the sun's diameter is sufficient to produce the heat it radiates. More accurate recent measurements of the amount of heat radiated, indicate a greater contraction—a lessening of the sun's diameter by 300 feet annually.

This, even, is so slight a change in that diameter of near a million miles that in seven thousand years it will not appreciably alter the sun's apparent breadth. Our present most exact heliometers could not then detect the change—a change in the sun's angular breadth in seven thousand years of less than a single second!

But as the sun is a gaseous mass, its expanding force just counterbalanced by its gravitating force, it can contract only as its expanding force lessens by loss of heat readiated.

Will it not then cool as it contracts? Not necessarily. For Lane's law, discovered about 1870, asserts the paradox

that a globe of gas contracts by its own gravity and grows hotter, as necessary results of losing the heat radiated.

To illustrate: Let v = volume of a globe of gas; p = its surface gravity, or pressure; and t = its absolute temperature. When from loss of heat by radiation its radius contracts one-half, let v', p', t' represent respectively its changed volume, pressure, and temperature.

Since volumes compare as their radii cubed, and surfaces as the radii squared, v' will = $\frac{1}{8}v$; and the surface of v' will = $\frac{1}{4}$ the surface of v.

Since surface gravity increases as the square of the radius diminishes, the inward pull or pressure on the surface of v' will = 4 times what it was on the surface of v; and as just shown, the surface of v' is only one-fourth that of v. Therefore, as a 4 times greater force will be exerted on a 4 times smaller surface, on a unit of surface the force or pressure on v' is 16 times the former pressure on v. That is, $p' = 16p$.

As is well known for a gas the product of its volume and pressure changes as its temperature changes.

Hence, $v \times p : v' \times p' :: t : t'$,

or, $v \times p : \frac{1}{8} v \times 16p :: t : t'$,

or, $1 : 2 :: t : t'$,

or, $t' = 2t$.

Thus, when contracted to half its radius the globe of gas is twice as hot as at the outset. In general, as it radiates heat it contracts, and as it contracts it grows hotter.

If, then, our sun is truly gaseous from centre to surface, notwithstanding its vast output of heat it must, by contraction, continually grow hotter.

If, however, as is likely, the photosphere of incandescent clouds of carbon droplets and the central density have made it partly viscous, or partly liquid, or even semi-fluid, then the heat produced by contraction may just equal that lost by radiation.

In this case the sun's temperature will be constant—as probably it has been during the historic past.

With increased condensation, the heat of contraction will fail to replace that lost by radiation, and the sun's temperature will lower more and more until it becomes cold, solid, dark!

When by contraction its present diameter is reduced one-half, its density will be increased eight-fold. It may then be non-gaseous, and will doubtless be cooling. Contracting still, cooling more, radiating less and less heat, it must finally fail to support any of the present forms of terrestrial life—the world we know will be dead!

It is somewhat comforting to learn from Newcomb and from other eminent authorities, that this sad failure of our now glorious Day-Star, when its generous heat and light shall be quenched—our world's night of death—is probably distant in the future some ten million years!

56

JOURNAL

OF THE

Elisha Mitchell Scientific Society

VOL. XXII NOVEMBER, 1906 NO. 3

PROCEEDINGS OF THE FIFTH ANNUAL MEETING OF THE NORTH CAROLINA ACADEMY OF SCIENCE HELD AT RALEIGH, N. C., MAY 18 & 19, 1906.

Friday, May 18th, 1906.

This evening was devoted to a joint meeting of the Academy and Chemical Society in the Auditorium in the Agricultural Building at which the Presidential address upon the subject: "The Source of the Sun's Heat" was delivered by Prof. John F. Lanneau of Wake Forest College. The address was followed by a smoker.

Saturday, May 19th, 1906.

A meeting of the Exucutive committee was held. The following members were present: President John F. Lanneau, Secretary F. L. Stevens, and Professor Collier Cobb.

The following members were nomitated to the Academy by the Executive Committee: Mr. J. C. Temple, of the A. & M. College, Mr. F. C. Reimer, of the A. & M. College, Dr. E. W. Gudger, of Greensboro, Dr. Archibald Henderson, of Chapel Hill, and Mr. R. S. Woglum, of Raleigh.

Printed December 8, 1906.

A business meeting of the Academy of Science followed. The minutes of the last meeting were read and approved. The two following amendments previously submitted to the Executive Committee were received and adopted by the Academy:

1. To strike out of Article 2, Section 1, all of the second paragraph.

2. To strike out from Article 2, Section 2, the following words: "Three dollars and for associates."

The names of the following persons previously accepted by the Executive Committee were received and the candidates elected to membership in the Academy: J. C. Temple, F. C. Reimer, E. W. Gudger, Archibald Henderson, and R. S. Woglum. A nominating committee previously appointed reported the nominations as follows: For President, Professor Collier Cobb; Vice-president, Professor J. L. Lake; Secretary-Treasurer, F. L. Stevens; members of the Executive Committee in addition to the ex-officio officers, Dr. W. C. Coker, Franklin Sherman, and Professor J. F. Lanneau. The report of the Committee was adopted and members named declared elected to the respective offices.

The report of the treasurer showing the balance of $141.43 was received. Mr. C. B. Williams was appointed as auditor.

Following the business meeting was held the meeting for the presentation of papers, a summary of which follows:

Autophytographs, ... Collier Cobb

Name suggested by C. H. White (Am. Jour. Sci., March, 1905) for a plant record formed by the extraction of coloring matter through decay of plant, or a black deposit reproducing perfectly the leaves of the plants, illustrated by specimens from the neighborhood of Wilkesboro, N. C., and elsewhere. Such records have also been made in geological past, and Professor Cobb reported fern autophytographs on carboniferous rocks from near Pottsville, Pa., exhibiting two different specimens of the same.

Notes on the Variation in the Number of Eggs or Young Produced by Some American Snakes . . C. S. Brimley

This paper gave the largest, smallest, and average number of eggs or young produced, according to the author's experience by the following species of American snakes: Eutoenia sirtalis, Eutoenia saurita, Natrix sipedon, Haldea striatula, Storeria dekayi. Storeria occipitomaculate, Virginia valerioe, Bascanium constrictor, Heterodon Platyrhinus, Ophibolus getulus, Cyclophis aestivus, Coluber quadrivittatus, Carphophiops Amoenus, Ancistrodon contortrix, Ancistrodon piscivorus. Comments are also made on the confusion caused by the application locally of the same popular or local name to different species of snakes in different places, and by different names being applied to the same species.

The Embryo-sac of Liriodendron . . . . . . W. C. Coker

The development and structure of the embryo-sac of the ordinary tulip tree, Liriodendron, was explained with blackboard drawings. The special point of interest was that though this tree is ancient geologically, yet its embryo-sac presents no unusual features.

Sugaring for Moths . . . . C. S. Brimley

The author's experience in sugaring for moths in July, August, and September, was given. Names of the mixtures employed and how applied, and what species of moths and other insects were captured. Notes that a very large proportion of the attracted moths were species of economic importance, viz., the army-worm and cutworm moths, which do considerable injury to field and garden crops. Notes what insects were attracted to the sugared patches in the day time and also that rough barked trees were better to sugar than smooth-barked ones.

Rhoetic Flora of Moncure Shales . . . . . Collier Cobb

Specimens of Liriodendron (?) reported from Deep River Trias in 1904 in association with Macrotoeniopteris, and then regarded by speaker as Lower Trias, led to the tracing of this bed eight miles northeastward through Lockville to Moncure, and to the discovery of one nearly complete Liriodendron leaf and several fragments in association with lycopods, conifers, and equisetaceae with many examples of more modern plants yet to be determined, constituting what is probably a transition flora. Many of the specimens were from a well recently dug by the Seaboard Air Line Railway.

The Influence of Citrous Stocks on Scions Mr. F. C. Reimer

An investigation was made in Florida to determine whether the stock influences the scion in any way. The following outline covers most of the work which was done:

1. Influence on rate of growth—(a) in diameter, (b) in height.
2. On shape of tree.
3. On hardness.
4. On diseases.
5. On fruit—(a) amount, (b) quality, (c) season of ripening, (d) color, (e) dropping.

Interesting results were obtained which will appear in *Science* in full at a later date.

Mr. J. C. Temple discussed the bacterial flora of cow manure, showing the average number of germs present in fresh manure and in manure of different ages. The relation of these various germs to the nitrogenous material of the manure. He also presented important results concerning the distribution abundance and variation of the colon bacillus.

A paper by Lewis T. Winston in his absence was read by Dr. F. L. Stevens on "Bacterial Analysis of Various Lithia

Waters," in which it was stated that while most of the lithia waters were above reproach from a bacterial view point, some of them are of such condition that if submitted to the ordinary board of health analysis they would be condemned.

Liverwort Types for Elementary Classes . . W. C. Coker

It was suggested that Pallavicinia, on account of its simple structure and easily demonstrated organs was far more suitable for elementary work than the more complex Marchantia which is generally used. Frullania Virginica was suggested as the best type for use in demonstrating the development of the capsule.

Mr. W. C. Etheridge explained a series of tests which he had made concerning the various methods of analysis of milk to determine the effect of the various media, various ages of plate, different degrees of acidity, and effect of ventilatiou upon the bacterial count.

Mr. C. S. Brimley presented a paper on the "Zoology of Lake Ellis, Craven County, N. C."

The Endosperm of the Pontederiaceae . . . . W. C. Coker

It was shown that the endosperm of the three genera of this family so far investigated was of two sorts. The definitive endosperm nucleus on its first division forms a wall separating the sac into an upper and a lower part. The endosperm in the upper part is quite different in appearance from that in the lower.

Food Adulteration . . . . Mr. W. M. Allen

This paper showed the great effect of the adulteration of human foods on mankind; how it affects both the health and the wealth.

It seems that the greatest danger to health lies in the use

of chemical preservatives in fresh meats and sausages by butchers and meat men, often ignorant, having no conception of what they are dispensing to their customers.

The meeting was well attended and interest was manifest.

Following the meeting for the presentation of papers the Academy of Science and the Chemical Section adjourned to Giersch's café where the visiting members were entertained at lunch by the Raleigh members of these two organizations.

F. L. STEVENS,

SEC. & TREAS.

THE BUILDING AND ORNAMENTAL STONES OF NORTH CAROLINA, A REVIEW.

BY JOSEPH HYDE PRATT, STATE GEOLOGIST.

There has recently been published by the North Carolina Geological and Economic Survey a report on the Building and Ornamental Stones of the State, which was prepared by Prof. Thomas L. Watson and Francis B. Laney, with the collaboration of Dr. George P. Merrill. This report represents nearly three years of field and laboratory work and shows that North Carolina is well supplied with a great variety of building stone materials, particularly those of a granitic type. With perhaps the possible exception of Georgia, it is better supplied with both as regards quality and variety than any of the other Appalachian States south of New England. When this fact is taken in connection with the mildness of the climate, which permits a long season of outdoor labor, and with the cheapness of labor itself, it will undoubtedly result in the development of a very extensive industry.

The granitic rocks have been especially studied by Dr. Watson, who worked almost exclusively in the granites and gneisses, with incidental reference to the associated eruptions, the diorites, diabases, and gabbros. In connection with the field work on these granitic rocks, he was ably assisted by Mr. Laney, who, however, devoted the larger part of his time to the marbles, limestones, sandstones, serpentines, and road materials,

Dr. Merrill's guiding hand is plainly seen in the character of the work and its form of presentation. There were but few tests made to ascertain resistance to crushing, shearing,

elasticity, or absorption, chiefly because the report does not pretend to be either exhaustive or final, but has been published to call attention to the deposits of stone, especially those of known economic importance, and to indicate how these can be opened and operated profitably. No chemical analyses were attempted, nor were they for the most part considered essential for the present work, as Dr. Merrill still adheres to his opinion that more can be learned from an examination in the field than through all known laboratory tests taken together. There are a number of chemical analyses given throughout the report which have been taken, however, from previous reports of the Survey.

The volume is divided into nine chapters, with a short appendix on stones for road buiding. In Chapter I, which is entitled Preliminary Generalities, the essential qualities of building stones are thoroughly discussed, attention being called to the influence that color has on the market value of a stone; the ease or difficulty with which a stone can be worked, and the location of the deposit with respect to transportation facilities. The surface features of the State are considered and it is shown that the geological formations which are capable of yielding desirable stone for structural purposes or ornamentation traverse the State in northeast and southwest directions. Beginning at the western margin of the coastal plain, there is found extending northeast from Raleigh a broad belt of gneissic rocks, succeeded on the west by one of brown sandstone, and this in order by belts of schist, granites, and gneisses to the State line, the last mentioned belt carrying in Cherokee, Graham, and Swain counties a narrow belt of marble. Within these areas there are numerous minor exceptions to the regular order mentioned above. The geographic position of the State is considered with reference to other than local markets and it is clearly shown that North Carolina is near the center of an area containing hundreds of large and prosperous cities and towns which will afford a market for a much larger amount

of building stones than it is now supplying, which should result in the development of the quarry industry on a much larger scale and without any danger whatever of ruinous competition.

Chapters II, IV, and VI take up in detail the building and decorative stones roughly classified as follows: (1) The crystalline siliceous rocks, including the granites, gneisses, and diabases, or traprocks; (2) the calcareous rocks, including all limestones and dolomites, both the crystalline and compact common varieties; and (3) the fragmental or clastic rocks, including the sandstone and clay slates. Those of the first group result either as erupted molten matter from the earth's interior or from the metamorphism of siliceous sediments. Those of the second group originate mainly as deposits of calcareous mud from the breaking up of shells, corals, and the remains of other marine animals on an old sea bottom. Those of the third group result from the breaking up of older rocks, and the accumulation on the bottom of lakes and seas of the resultant sand, clay, or mud in beds of varying thickness, to be subsequently hardened into stone.

"Now the essential difference between a marble and a compact common limestone, like those of Ohio or Kansas, is that the first has undergone, through the combinded action of heat and pressure, just the right degree of change, or metamorphism as it is technically called, to develop in it crystallization and color; the essential difference between a brick or fire clay and a cleavable slate suitable for roofing, is, as explained elsewhere, that the first named still retains its plastic condition as it was laid down in the form of fine silt on a sea bottom, while the slate has by geological agencies, by actual movements of the earth's crust, been so squeezed and compressed as to lose all resemblance to its former self, and become the cleavable article of commerce we now find it.

"These processes of change, as noted above, are dependent very largely upon the actual movements; warpings and foldings as one might say, of the earth's crust and the heat and

chemical action which is thereby generated, and since these movements take place only with extreme slowness, whole geologic ages being occupied in their inception and completion, it follows as a matter of course that these metamorphic rocks, these gneisses, marbles and roofing slates, are found only among the older rocks and only in those portions of the country where this crust has been warped, compressed, and folded as in the process of mountain making."

Thus, one will find these rocks in their best development in those regions bordering along more or less extensive mountain ranges.

The area of the State containing rocks of the first class is very extensive and includes the three larger physiographic provinces of the State, namely, the coastal plain, the Piedmont plateau, and the Appalachian Mountain; but the greater part of the granites and other crystalline rocks of economic importance are included in the Piedmont plateau region. Along the inner margin of the coastal plain region there are a number of small workable areas of granite of excellent quality; but in the mountain region the large granitic areas are usually schistose in structure and are not very desirable for the higher grades of work in which granites are used. These crystalline rocks are discussed in groups:

I. The Coastal Plain Area, this area including Wilson, Edgecombe, Nash, Anson, and Richmond counties. In this region the areas capable of producing workable granite either lie close to or are crossed by the principal lines of railroad in the eastern part of North Carolina, rendering them easily accessible and providing ample facilities for transportation of the stone. The outcrops are usually large and are so located as to offer advantageous quarry sites. They are all biotite granites, showing a considerable range of variation in color and texture, from light gray to pink with occasionaly a mixed yellowish and pink appearance. No systematic quarrying has as yet been undertaken and all that has been quarried has been used locally.

II. The Piedmont Plateau Region.

1. The Northeastern Carolina Granite Belt, including Wake, Franklin, Vance, Granville, and Warren counties. In this belt extensive workable areas of different grades of granite are found suited for all grades of work in which granite is used, except for the better grades of monumental work. Systematic quarrying, however, has been limited to areas in and around Raleigh, Wake county and at and near Greystone and Middleburgh, Vance county. These quarries have been operated quite extensively, furnishing stone to Eastern Virginia and Carolina, principally in the form of blocks and curbing for street purposes; and for general building purposes. Throughout this belt the granites show but little variation in mineral composition and, with one exception, they are biotite-granites. Minerals such as free sulphides and iron oxides, which are a source of discoloration to stone on exposure, are practically absent from the granites of this belt.

2. The Carolina Metamorphic Slate and Volcano Belt, including Orange, Durham, and Chatham counties. The country rocks of this belt comprise argillaceous, sericitic and chloritic metamorphosed slates and crystalline schists; sedimentary pre-Juratrias slates; and ancient volcanic rhyolites, quartz porphyries, and pyro-clastic breccias that are often sheared and altered andesites. Rocks of granitic composition have as yet only been noted in Orange county, and they are of doubtful commercial value except for railroad ballast and road purposes.

3. The Carolina Igneous Belt (The Main Granite Belt), including Mecklenburg, Gaston, Cabarrus, Iredell, Rowan, Davidson, Davie, Forsyth, Guilford, and Alamance counties. In this belt granite is one of the principal and most widespread rocks, and in each of the ten counties included in the belt, extensive areas of granite are exposed. Outcrops of firm and hard moderately fresh granite are not uncommon, and as a rule the exposures are large enough to admit of the

opening of large quarries without much stripping. The stone is usually well suited to the many purposes for which granite is used, and the belt is traversed in nearly all directions by lines of railroads which offer ample facilities for transportation. Notwithstanding these conditions, only a limited amount of quarrying has been done in these counties,

Figure 1. Boulder outcrop of orbicular-gabbro diorite, Hairston farm, Davie county, 10 miles west of Lexington, Davidson county.

with the exception of Rowan, where systematic quarrying has been developed on a large scale on the Dunns Mountain granite ridge.

There are two distinct phases of the granite developed, an even granular or normal and a porphyritic granite, both of which have wide distribution within the limits of the belt and, with one exception, represent different phases of the

same rock mass, the porphyritic texture grading into the even-granular. With hardly an exception the granites are mica (biotite) bearing and they vary in color from nearly white, through the lighter to the darker shades of gray. In several places over Dunns Mountain a beautiful shade of pink granite is quarried. This stone has attracted a great deal of attention aud is much admired as a decorative stone.

4. The Western Piedmont Gneiss and Granite Belt, including Surry, Wilkes, Alleghany, Alexander, and Cleveland counties. In this belt the massive granites are less abundantly distributed than over other parts of the granitic areas. They are all biotite-bearing, usually of light color and of medium texture. No injurious minerals are, as a rule, observed. The rocks possess marked strength and durability and are very desirable granites for certain grades of work. Mt. Airy, Surry county, one of the principal localities in this belt yielding rock of this type, constitutes the largest quarrying center in the State. The demand for this stone is rapidly increasing and wherever used has given entire satisfaction both as regards color and durability.

III. The Appalachian Mountain Region, comprising McDowell, Buncombe, Henderson, Madison, Jackson, Haywood, Macon, Transylvania, Swain, Mitchell, Caldwell, Watauga, and Ashe counties.

No systematic quarrying has as yet been undertaken at any point in this mountain region, but numerous small openings have been made in exposures of the rock in many places, but the stone has been used entirely for local purposes. The larger amount of the rock quarried has been used for ballast and road purposes. Transportation is the serious difficulty confronting the quarrying of the mountain granite for building purposes, except for local use.

The report shows that North Carolina is well supplied with granite deposits that are easily accessible and are of a

quality that will permit of their being used for all grades of work.

Some of the rocks included under the head of the crystalline rocks are of especial interest and are mentioned more in detail.

Orbicular Gabbro-Diorite:— The orbicular gabbro-diorite is found on the Hairston plantation, Davie county, ten miles west of Lexington and one mile west of Oak Ferry. It occurs in high boulders occupying a low indistiuct ridge, which culminates in a peak or knoll about thirty feet above the surrounding plain, Fig. 1. This is the only point where the orbicular rock outcrops prominently, but it can be traced in a southwest direction by means of residual decay for a distance of one-half to three-quarters of a mile in length and of several hundred yards in width. The orbicular rock undoubtedly occurs in the form of a typical dike penetrating the porphyritic granite and is parallel to and probably of the same age as some large, massive, unaltered diabase dikes in the vicinity which are intersecting the same rock..

This rock presents two distinct and strongly contrasted phases, one the pronounced orbicular and the other a granitic. Around the knoll referred to, the rock shows the typical orbicular texture, with the well rounded spheres varying in width from one-eighth to one inch and sometimes two inches in diameter. Some distance from the knoll the rock assumes a granitic texture, but is composed of the same minerals. Mineralogically, this rock is composed principally of a basic plagioclase feldspar, showing, as a rule, but slight polysynthetic twinning, uralitic hornblende, and diallage. Besides these, titanite, apatite, magnetite, and zircon occur as accessory minerals, and quartz, muscovite, calcite, and zoisite as secondary minerals.

In color the rock is dark, with a greenish tinge due to the dark green hornblende. It has a pronounced mottled appearance produced by the nearly black green nodules of hornblende in a ground-mass of the intensely white plagioclase feldspar.

The contrast is very pleasing and it is brought out much more prominently in the cut and polished surfaces. The spheres

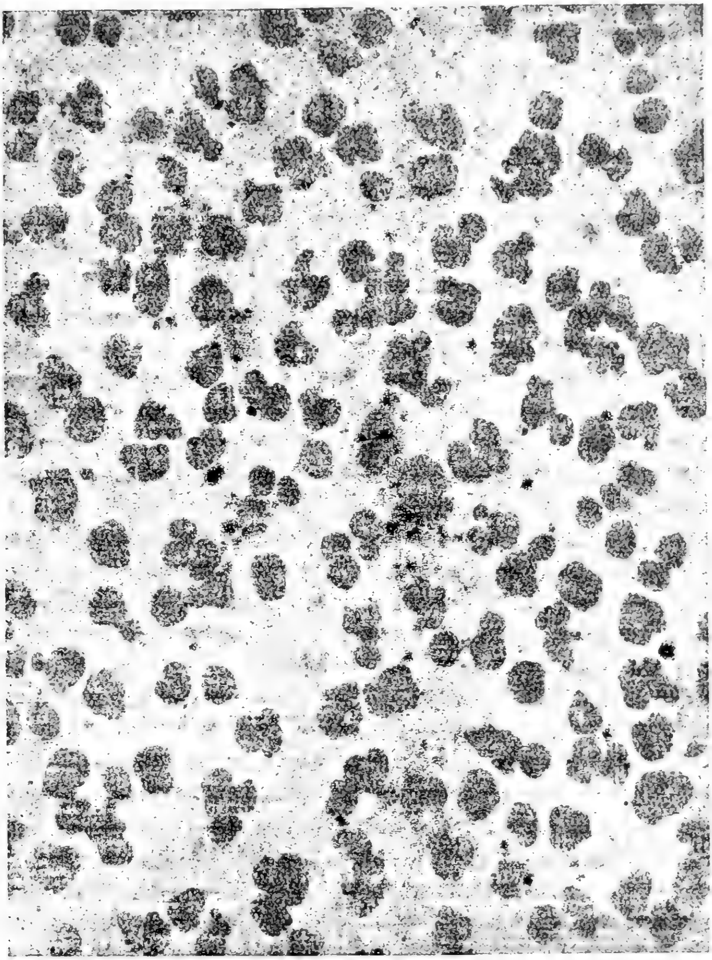


Figure 2. Photograph of fresh surface of leopardite showing the stone when broken at right angles to the long parallel streaks or pencils of a dead black color.

usually exhibit a fibrous, radiating structure from a common center outward. In some instances a small fragment of feldspar, quartz, or pyrite has been the nucleus about which the spheres of the hornblende have been formed. The concentric structure which is usually observed in orbicular rocks is not at all pronounced in the North Carolina rock; and where the spheres of orbicular granite and diorite heretofore described are composed usually of a number of minerals, the North Carolina rock is only composed of one, the dark green hornblende.

As a decorative or ornamental stone, this unique stone should find very great favor. It works easily and well as is shown by a polished column and sphere that are in the State Museum at Raleigh. That it wears well is demonstrated by the fact that some of this stone quarried prior to the Civil War and used for gate posts and steps to the house on the Peter Hairston property, do not show any signs of decay.

Quartz-Porphry (*Leopardite*):— Intersecting the biotite-granite at Belmont Springs 1½ to 1¾ miles east of Charlotte, Mecklenburg county, is a dike of quartz porphry about one-half mile long, whose width nowhere exceeds 25 feet and which has been most appropriately named Leopardite. It is a dense, hard, tough and compact cryptocrystalline rock, which breaks with a conchoidal fracture. The fresh rock is nearly pure white, tinged in places a very faint greenish, and penetrated by long parallel streaks or pencils of a dead black color. If it is broken at right angles to these streaks, the surface is dotted with rounded irregular black spots varying from pin heads up to half an inch in diameter. This peculiar spotted appearance is well illustrated in Fig. 2. When the rock is broken or cut parallel with the direction of the pencils, the surface is streaked with long irregular black lines, which are sometimes approximately parallel and at others assume a dendritic or fern-like appearance, as illustrated in Fig. 3. These black streaks or pencils are not regurlarly distributed throughout the quartz-porphry, but in

some areas they are entirely absent, while in others they are crowded very closely together.

Mineralogically the rock is composed essentially of feldspar, both potash and plagioclase varieties, with a smaller amount of quartz,, which forms minute irregular interlocking grains. Considerble of it is intergrown with the feldspar in micrographic structure, forming more or less rounded disk-like areas. The black streaks or pencils are composed of oxides of manganese and iron and are supposed to represent the percolation of manganese and iron solutions through the rock.

The rock is susceptible of an excellent polish and could be used with splendid effect in inlaid work. On account, however, of its exceeding hardness and toughness and absence of any definite rift, it will be a rather expensive stone to quarry.

Unakite:— In Madison county, about 5 miles southwest of Hot Springs, there is an irregular area of granite containing epidote as a characterizing mineral. The main mass of this rock is described as a dark pink and green epidote-biotite-granite of coarse texture and somewhat schistose structure varying from a typical schistose granite in which the quartz is present in the usual amount to a nearly quartzless rock of the same color and texture.

Penetrating this granite probably in the form of narrow veins is the unique and beautiful variety of granite known as unakite. This rock is composed of yellow-green epidote, dull pink or red feldspar and quartz. The unakite is not uniform in color and composition, but shows pronounced gradation into a highly feldspathic rock of pink color on the one hand and an epidote rock of a yellow-green color on the other. Usually in the veins the normal unakite, which is a coarse, massive rock of even texture, occupies the middle portion of the vein and graduates toward the enclosing gneiss either into the feldspathic or epidotic rock or both.

Under the microscope the unakite is shown to be composed of the usual granitic minerals such as orthoclase and

microcline in nearly equal proportions, a little plagioclase, quartz, occasional biotite, zircon, apatite, rutile, magnetite,

Figure 3. Photograph of a section of the leopardite cut parallel with the direction of the pencils.

and a few small grains of pyrite, with the secondary minerals epidote, chlorite, kaolin, and a green mica.

One of the best exposures of the unakite in its relation to the other granitic rock is along Roaring Fork and a short distance above its entrance into Meadow Fork. The commercial value of the rock would be for decorative or ornamental purposes, but at the present time it has not been developed sufficiently to determine what quantity of this rock can be obtained commercially.

In Chapter III there is a short description of the dikes and veins penetrating the crystalline rocks previously described which include, beginning with the most acid, true quartz veins, pegmatite, aplite and granite dikes of normal composition and texture; and abundant dikes of basic igneous rocks, of which diabase and diorite are the most common types.

Chapter IV treats of the calcareous rocks, limestones and marbles, taking up in detail their varieties, structure, weathering qualities, uses, and geographical distribution. The marble localities are confined to Cherokee, Swain, McDowell, and Mitchell counties. The only ones that have been developed commercially are those in Cherokee county. The marble of Mitchell county is perhaps worthy of more detailed notice on account of its occurrence and quality.

White Marble from Mitchell County:— This marble was first exposed in a railroad cut on the north bank of North Toe River near the mouth of Sink Hole Creek about 3½ miles above Toe Cane Station. The marble is exposed in a bed about 60 feet thick interbedded with typical mica schists, and is exceptionally pure and of very uniform texture. As far as can be judged from the exposure of the blocks that are blasted out, it is remarkably free from joints, It has a beautiful pure white color and takes a good polish. It can be traced northeastward from the outcrop at the railroad for about a mile and is favorably located for quarrying, being on a mountain side about 100 feet above the valley, thus affording natural drainage and space for disposal of waste

material. Considering the location of this marble and its texture, purity, and color, it offers a very favorable commercial quarry proposition.

One peculiar feature of this marble deposit is the occurrence of a large pegmatitic vein in the midst of the marble as illustrated in Fig. 4.

The limestone areas are rather scarce throughout North Carolina and in no place are they of sufficient magnitude to be of any large commercial importance either for building purposes or for burning into lime. In a few localities a small

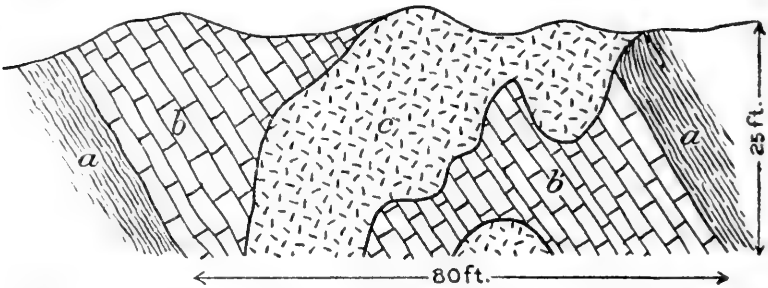


Figure 4. Pegmatic dike (c) cutting the Mitchell county marble (b). The country rock is a contorted typical mica schist (a) which at its contact with the marble is quite calcareous.

amount of the stone is used for road purposes or burned into lime for local use. In Buncombe county, about 2 miles north of Fletcher, two kilns having a capacity of 700 bushels per day have been erected for burning a limestone that is of a peculiarly fine grained structure, containing little or no impurities, the analyses giving 95.32 per cent. calcium carbonate.

The serpentines and verdantique marbles are described in Chapter V. They are at the present time of no commercial importance and they have been described in detail in a previous report of the North Carolina Geological Survey on Corundum and the Peridotites of Western North Carolina.

The sandstones and quartzites, which are taken up in

Chapter VI, are discussed more from a commercial than a scientific standpoint. Although in previous years there has been considerable quarrying of the sandstone from Moore county, in recent years the industry has come nearly to a standstill. This, however, has not been on account of the quality of the sandstone as much as transportation difficulties.

The dikes penetrating the sandstones are taken up in Chapter VII, which contains tables showing their distribution and their relation to the jointing of the sandstone.

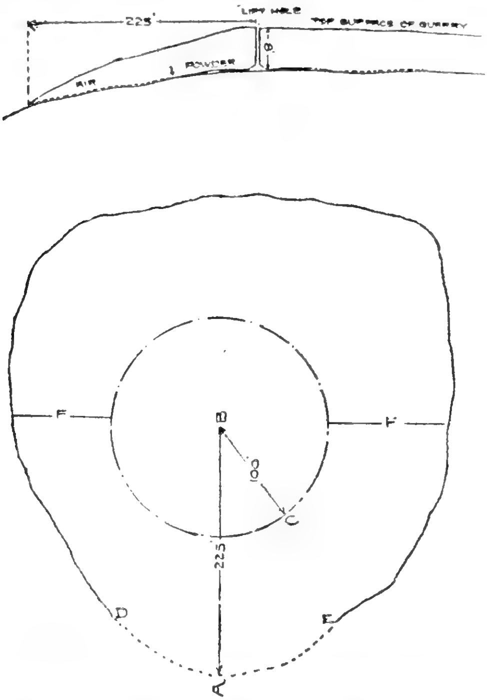


Figure 5. Diagram illustrating method of cleaving granite by means of compressed air. B, lift or drill hole; BC, area cleaved by powder; AFF, area cleaved by compresse air; DE, thin edge on down hill side of quarry where air escaped.

Chapters VIII and IX relate to the quarrying, working and weathering of building stones. One interesting method of quarrying building stones that is especially mentioned is that used by the North Carolina Granite Corporation at its Mt. Airy quarries, which is described as follows:

"In the center of the sheet or area to be lifted a drill hole 2 to 3 inches in diameter is sunk 6 to 8 feet depth, depending on the greatest thickness of stone required, and the operation is continued by the discharging of successive small amounts of powder similarly as described under the method of quarrying by using water* until the crevice extends a distance of 75 feet or more from the hole in all directions. A pipe is then cemented into the hole and connected by means of a globe valve to an air pipe line from an air compresser. Compressed air at 70 to 80 pounds pressure is gradually admitted and the cleavage rapidly extends until it comes out upon the hillside in a thin edge as indicated by the cross-section, Fig 5. A sheet of several acres in extent may be raised in this manner, affording a bed plane approximately horizontal, to which the quarrymen can work, thus securing stone of any required thickness. The first time compressed air was used a pressure of 80 pounds was admitted into the cavity which had previously been extended to a distance of 100 feet from the

*After being drilled, the hole is fired by a succession of light blasts using in the first charge about a handful of blasting powder. The operation is begun by discharging about a quarter of a pound of dynamite in the bottom of the hole. This small charge of dynamite pulverizes the stone slightly at the bottom of the hole and forms a small chamber. The tamping is then cleaned out of the hole which is recharged in the same manner, this time, however, using about a handful of powder. The recharging of the hole is continued with small charges of powder until a small seam has been started at the bottom of the hole extending parallel with the surface. This is found out by using a small steel rod bent at the lower end and sharpened to a point and passing it up and down the hole until the crack is located. After the crack has once been started, the use of light charges of powder is continued, increasing the charges gradually as the seam is found to extend in all directions from the lift hole until the crevice eztends a distance of 75 feet or more from the hole.

lift-hole. The power of the air, however, was too great for the easily splitting stone and the cleavage turned abruptly to the surface. In the next hole, however, the compressed air was admitted very gradually and the stone could soon be heard cracking in all directions and in about half an hour the cleavage came to the surface of the hillside as a thin edge some 225 feet from the lift-hole. To extend the cleavage by means of powder for a hundred feet would require from 6 to 12 days, and with water from 3 to 5 hours, while with the compressed air the larger area was split in half an hour.

Appended to the volume is a short description of stone found throughout the State that is suitable for road building, together with a table showing the results of tests made on certain stones suitable for use in road building.

Although this volume deals especially with the economic and commercial phases of the building stones of North Carolina, making it particularly interesting and valuable to contractors, builders, and dealers in building stones; yet there is sufficient detailed scientific work included to make it of considerable interest and value to the student of North Carolina geology.

WHERE THE WIND DOES THE WORK.*

BY COLLIER COBB.

No portion of the North American continent is so widely known, and at the same time so little known, as the chain of low-lying islands and fringing sand-reefs extending along the North Carolina coast for a distance of more than three hundred miles. This is especially true of Hatteras Island, a sand spit whose dangerous projection and shifting shoals have made this portion of our Atlantic seaboard a veritable graveyard of American shipping.

Distinguished scientists on both sides of the Atlantic have discussed the origin of Cape Hatteras without having set foot on the island or coasted along its shores. The origin of well nigh all the features of this coast have been discussed at long range, and yet hardly half a dozen people from the outside world have any personal acquaintance with the island.

It was on this coast that Fessenden and Thiessen experimented successfully with wireless telegraphy. At Kitty Hawk, on these banks, the Wrights conducted their experiments in mechanical flight.

Though difficult of access the inhabitants of these islands are in close touch with the rest of world by the telegraph and telephone lines of the U. S. Weather Bureau and the Life Saving Service as well as by the wireless telegraph.

Those who watch the reports of shipping need not to be told that winds are constant in this region. The strong winds of midwinter come from the north, and the gentler steady

*This article appeared in the *National Geographic Magazine* for June, 1906, with map and nine illustrations in half-tone from photographs, and is here reprinted with the permisson of the editor of that magazine.

winds of midsummer and of the greater part of the year blow usually from a little west of south.

These constant winds were early taken advantage of by the inhabitants, and windmills for grinding corn dot the whole chain of islands, though most of them have now fallen into disuse. A small boy on Church's Island hauls freight for the people of his village on a car furnished with a sail and propelled by the wind.

The frequency of wrecks upon this coast is too well known to require comment; though such is the efficiency of the life savers, who brave the perils of any storm, that life is rarely lost here. But the lightship has sometimes been broken from its moorings on Diamond Shoals and driven upon the Hatteras Banks.

The strong north-winds pile the sands up into great barchanes or medanos, cresentic sand-dunes, known locally as whaleheads, which are steadily moving southward. These are best developed along the Currituck Banks, from Virginia as far south as the Kill Devil Hills, and numbers of them may be seen to the north and to the south of Currituck Light. These whaleheads are composed of singularly homogeneous blown-sands, the horns or cusps pointing to leeward, which is almost due south.

The prevailing winds from a little west of south have rippled the heterogeneous sands on Hatteras just south of the cape, on Shackleford at its southwest extremity, and on the southwest side of Smith's Island. These wind-ripples, started in sands exposed by the removal of a strip of forest next the shore, have grown in size to great sand waves and are advancing on forests, fields, and houses. As the sand-wave has advanced, it has taken up several feet of the loose soil over which it has passed, undermining houses, laying bare the roots of trees, and exposing the bones of the dead in the cemeteries.

Diurnal winds from the sea have piled the sands into small wandering dunes and hillocks, and even sometimes into sand

waves which are marching steadily inward and shoaling the waters of the sound. At Nag's Head, a large hotel constituting a solid obstruction, soon had a sand wave built up a short distance in its rear until the level of the roof was reached, when the wave moved forward and engulfed the hotel. In the immediate neighborhood two cottages suffered a similar fate. Here the land gained on the sound three hundred and fifty feet in ten years.

On the northern end of Hatteras Island a fishing village has been similarly buried, while the sand has entirely crossed the island at several places north of the cape. This movement of the sand was started just after the Civil War by the cutting of trees next the shore for ship timbers, and the section is still known as The Great Woods, though not a stick of timber stands upon it today. Pamlico Sound for two miles from the Hatteras shore is growing steadily shallower from the deposit of blown sand.

On Smith's Island a pilot's village has been buried beneath the sand wave for a number of years, but this has been qnite recently resurrected and its hcuses are again occupied. On Currituck, below Caffey's Inlet Life Saving Station, the sand has advanced entirely across the land, and one man moving his home before the advancing sand has at last built his house on piles in the sound.

The writer has found by experiment that heterogeneous sands, consisting essentially of quartz, orthoclase, some mica, iron, bits of shells, and many mineral substances showing little if any decomposition,* ripple readily in the wind and are easily arrested. This he accomplished in one instance by planting the seed of a native pine and covering the dune with brush. In another case the movement was checked by the unassisted growth of grass upon dunes from which hogs and cattle were fenced out. Several native grasses on these islands are excellent sand-binders; but so far he has found no

*I consider these sands to be of glacial origin, scraped off the granite rocks of New England by the ice-sheet of the last glacial epoch.—C. C.

means of checking the movement of homogeneous sands that do not ripple, these consisting entirely of well rounded and wind-sorted quartz grains of the same size throughout a single dune.

Other trees beside the pine may be used as sand binders. Some live oaks and myrtles serve well in this capacity, and on Hatteras Island young olives and palms have been observed growing on the dunes, though this is the northern limit of both these trees, and they are even unknown on Ocracoke Island next to the south.

As already pointed out, the movement of these sands was in every case started by the deforesting of a strip of land next the shore; but in several instances nature has herself grown forests on dune sands. Above Kitty Hawk Bay large dunes are covered with a growth of pine, maple, oak, cedar, sassafras, locust, elm, beech, persimmon, sycamore, hickory, and in the damp interdune areas cypresses and gums. Here are many veteran pines, some of them having attained a diameter of three feet. An essentially similar forest is found growing upon the high dunes to the southwest of Cape Hatteras, bnt here we have to add the olive to the list, and there are broad interdune palmetto swamps.

On Bogue Banks, where deforesting has only just begun at two points, we have 20 miles of woodland, the virgin forest extending down to the water's edge and preventing the formation of dunes.

From Southport westward into South Carolina the dunes have moved northward and inland in some places completely filling the lagoons. At one point such a filled lagoon has produced a pine forest in something more than forty years.

The checking of these moving dunes presents a problem of increaing importance not only to the inhabitants of these sand keys, but to the navigators of the inland water-ways as well, and it is interesting to know that its solution is at hand, and that the encroachment of the sand may be effectually stopped.

It is fortunate that the strong north winds that pile up the sands and the strong east winds that cause the greater amount of the sand movement blow in the winter months rather than in the season of plant growth. The spring rains are usually of light intensity and long duration, and on Hatteras Island at least they come with the gentler southwest winds. Hence it is comparatively easy to plant grasses and shrubbery in late winter or early spring and have them gain a firm footing and accomplish something of their growth before the strong winds come.

In January, 1886, the writer planted the seed of the loblolly pine on the back of a dune and covered the area with brush cut from a near-by road in process of making. The brush served not only to break the wind bnt to conserve the moisture of the sands, and today there is a forest of several acres where twenty years ago was a moving sand waste. The method so common abroad of building a barrier dune by means of wind breaks has been tried several times along this coast, but always without success.

The atmospheric humidity of Hatteras Island is greater than that of any other station in the United States except in the Puget Sound region, and even there the excess over Hatteras is not great. Yet there are more days of sunshine on Hatteras than at Cape Henry, or Norfolk, or Wilmington. The heaviest rains come between late July and mid October, after the plants have done most of their growing for the year and when plants in many parts of the country are suffering greatly from the drouth.

The people of these islands are not the slothful bankers and rude wreckers pictured in song and story. They are fair women and brave men, most of whom live and do for others, —lifesavers, heroes. Their homes are comfortable and well kept; they attend regularly upon the services of the church, and their children are in school for eight months of the year, for the inhabitants of Dare County have voted upon themselves a special tax for this purpose. The islanders have

herds of small wild ponies, and flocks of sheep and goats, as well as cattle, on some of the islands.

True some primitive customs are preserved among them, and some early English forms of speech. Their lodges used in fishing and hunting are built after the most primitive types of straw thatch, while a higher type, similar to that used in the village of Gabii in the days of Romulus and Remus, is used as a temporary residence during their camp meetings in the summer, and this higher type of dwelling is on Hatteras built of palmetto thatch.

There is no better type of the average man than the native North Carolina banker.

The possibilities of these islands are as yet undreamed of by their inhabitants and utterly unknown to the outsider, who visits only the most barren of them in the duck-shooting season.

The regaining of the shore strip by reforesting the sands, and the retention of the dunes that are devastating the meadow lands, would make of Hatteras Island, at least, a subtropical garden, where southern fruits and early vegetables once plentiful here might come into the market. The game still lingering among the wooded dunes would be greatly multiplied, and the herds of wild ponies now dwindling away would again increase in numbers. Then conservative lumbering could be added to the industries of the island.

It is also within the range of possibilities that the black beachsands which are concentrated by wave action at a few points might be made to yield from their iron ores a return for the labor of gathering them.

THE CORAL SIDERASTREA RADIANS AND ITS POST-LARVAL DEVELOPMENT.*

H. V. WILSON.

The Coral Siderastrea radians and its Post-larval Development. By J. E. DUERDEN†. Washington, U. S. A. Published by the Carnegie Institution. December, 1904. Pp. 130, with 11 plates.

This handsome Carnegie memoir contains the record of an investigation begun at the Institute of Jamaica and subsequently carried on at the Johns Hopkins University and the American Museum of Natural History in New York. The author's prolonged residence in the West Indies gave him unusual opportunities in the way of command over living material, and the memoir makes valuable additions to our knowledge on many points of coral morphology.

An introduction deals with the systematic zoology and the habits of the species which is abundant and accessible in Kingston harbor. The form is obviously one of those convenient, hardy types destined to play a part in laboratory investigations of histological and physiological character. Both the adult colony and the young polyp after metamorphosis grow in confinement and may be hand-fed. There follows an ample description of the anatomy of the adult. The species, like other West Indian corals, is possibly protogynous, although Professor Duerden calls to mind that Gardiner has established the converse phenomenon, protandry

*Reprinted from *Science*, N. S., Vol. XXIII., No. 587, Pages 497–498, March 30, 1906.

†Professor Duerden served as Acting Professor of Biology in this University during the year 1902–'03.

for *Flabellum*. Duerden takes up the question as to the way in which the coral skeleton, as a product of cellular activity, is produced. He confirms Miss Ogilvie's observation that the corallum can be seen in favorable parts of the adult and young polyps to be composed of minute skeletal units of a polygonal shape and exhibiting a fibro-crystalline structure. But whereas Miss Ogilvie interpreted these bodies as actual cells which were produced through the proliferation of the ectoderm, becoming calcified as fast as produced, Duerden regards them as secretory products which are laid down wholly external to the ectodermal cells. In support of this view, essentially that advanced by von Koch, Duerden finds that the layer of ectoderm concerned in the production of the skeleton is always a simple layer, and that, moreover, it is always separated from the corallum by a homogeneous mesoglœa-like stratum. It is in this stratum of homogeneous matrix that the author believes the calcareous crystals forming the skeleton are first deposited.

A third section deals with the post-larval development. The larvæ, of the usual coral type, were obtained in July, and were kept under continuous observation for some months after attachment. Many valuable facts concerning the succession of the tentacles, mesenteries and various parts of the corallum are recorded in this section. A feature of interest lies in the attention paid to individual polyps. The partial transparency of the young animal permits of instructive views during life, and thus in one and the same individual the correlated development of the various organs could be followed from day to day. A result of this method was that periods of rapid growth and relative rest could be distinguished. The author points out that a phylogenetic significance possibly attaches to some of the more persistent stages, such as, for instance, that in which complete pairs of mesenteries (directives) are found at the two ends of the œsophagus, with two pairs, each consisting of a long (complete) mesentery and a short one, on each side of the œsophagus. This condition

continued unchanged for a period varying from three weeks to three months. The author's theoretical views as to the meaning of this particular stage are summed up as follows:

> The long retention of freedom of the fifth and sixth pairs of protocnemes suggests to my mind an ancestry in which the mesenteries as a whole, including the metacnemes, were alternately long and short, excluding, of course, the axial directives. Among modern examples this is retained in the mesenterial system of the zoanthids, *Porites*, and *Madrepora*, and was perhaps characteristic of the Rugosa.

The building up of the corallum is followed out in detail throughout the formation of the third cycle of permanent septa. Among the illustrations of this part of the work special mention is due the microphotographs of macerated skeletons of developing polyps, and the figures of living polyps with the beginning skeleton *in situ*. Much interest attaches to Professor Duerden's account of the development of the septa. It has been hitherto assumed that the septa of a new cycle appear in the exocœles (*i. e.*, the space between two pairs of mesenteries), but are later embraced by the newly appearing pairs of mesenteries in such wise as to lie in the entocœles (*i. e.*, the space between the mesenteries of a pair). Thus the same septa would be first exocœlic and then entocœlic. In opposition to this scheme Duerden's observations lead him to the conclusion that while exosepta are formed in successive cycles, they never become entosepta. The cycles of entosepta are strictly new formations, appearing as do the primary six septa in entocœlic spaces. The succession of the cycles of exocœlic septa is maintained through the continued peripheral bifurcation of preexisting exocœlic septa. The bifurcated extremities become the (exocœlic) septa of a new cycle, while the main septa is incorporated in the growing body of one of the last formed cycle of entosepta. Having respect only to the actual facts as observed in *Siderastrea*, it has been found that any one of the permanent septa, later than the first six, has a double origin. It is in part a new formation (entocœlic), and in part a preexisting formation (exocœlic). The

two parts fuse, and the fusion is interpreted by Professor Duerden as the incorporation by a growing organ of the remnant of a vanishing organ. In a developing corallum according to this view exosepta are formed at each stage of growth, only to disappear as the permanent septa, entosepta, come into existence. Thus the development of coral septa affords an excellent example of substitution: temporary organs precede and are replaced by permanent organs performing the same function as the former. As a corollary to this conclusion the author expresses his belief that the exoseptal predecessors of the permanent septa do not wholly disappear in all corals, as independent structures, but persist in some species in the shape of the *pali* found in front of the larger septa.

CHLORAL—α—NAPHTHYLAMINE AND CHLORAL—β—NAPHTHYLAMINE.

ALVIN S. WHEELER AND V. C. DANIELS.

[Chemical Laboratory of the University of North Carolina.]

In an attempt to prepare condensation products of chloral with the two isomeric naphthylamines, we were able to obtain the addition products only. These latter were produced when the reaction was carried out at the ordinary, or better, somewhat reduced, temperature. If the reaction mass was heated to one hundred degrees in order to eliminate the elements of water and thus obtain a condensation product, the reaction went too far and black oily substances resulted. We studied the addition products, however, and found that they were formed by the addition of one molecule of chloral to one molecule of the naphthylamine. This work was done in the spring of 1905 and since the same compounds have recently been described [L. Rügheimer, Ber. d. deutsch Chem. Ges. 39, 1662] we wish to record our results, although we had intended to await further accumulation of material.

Chloral—α—Naphthylamine, $CCl_3CHOH.NHC_{10}H_7$.

Seven grams of chloral (M. W.=147) were dissolved in 10 cubic centimeters of cold benzene and 5 grams of α—naphthylamine (M. W.=143), dissolved in 15 cubic centimeters of benzene, were added slowly with constant stirring. By surrounding the beaker with cold water the temperature is kept sufficiently low. About 50 cubic centimeters of ligroin are next added, causing a very dense white crystalline precipitate. The yield of the dried product was 7.8 grams, the theoretical being 10.1 grams. The melting point of the crude substance

was 89°C. Purification was effected by dissolving in as small an amount of cold benzene as possible and precipitating with ligroin. Vigorous stirring for about ten minutes is of considerable assistance in causing a complete precipitation. The melting point was raised to 92°C.

The following analytical results were obtained:

I. 0.2265 gram substance was heated with 0.5908 g silver nitrate and fuming nitric acid in a sealed tube. 11 c.c. standard ammonium sulphocyanate solution (1 c.c.=0.0173 g $AgNO_3$) were used in titrating the excess of $AgNO_3$.

II. 0.2117 g substance gave 0.3900 g CO_2.

III. 0.2117 g substance gave 0.0727 g H_2O.

IV. 0.3697 g substance gave 17 c.c. nitrogen at 22°C. and under a pressure of 756 mm.

	Calculated for	Found			
	$C_{12}H_{10}ONCl_3$	I.	II.	III.	IV.
Cl	36.61	36.88			
C	49.58		50.24		
H	3.48			3.81	
N	4.83				5.32

Chloral—α—Naphthylamine is soluble in glacial acetic acid, alcohol, and benzene and slightly soluble in ligroin and ether. It is a white crystalline compound, the needle like crystals collecting in bundles like sheaves of grain. It is insoluble in water and turns black when the water is heated. It can not be long exposed to light.

CHLORAL—β—NAPHTHYLAMINE, $CCl_3CHOH.NH.C_{10}H_7$

Five grams of β—naphthylamine were dissolved in as little ether as possible and to this solution were added 7 grams of choral in 10 c.c. of ether. After concentrating the solution to about 20 c.c., ligroin was added in considerable quantity. A dense white precipitate of the addition product was immediately thrown down. On account of the difficult solubility of β—naphthylamine in ether, too much of it was used in our first work and the isolation of the product after the addition

of ligroin was troublesome. Rügheimer uses chloroform in place of ether in this preparation. The yield of pure substance was rather small, about 27 per cent of the theoretical.

The following analytical results were obtained:

I. 0.2289 g substance was heated with 0.6148 g silver nitrate. 1.53 c.c. of standard ammonium sulphocyanate solution (see) above) were used to titrate the excess of silver nitrate.

II. 0.2862 g substance gave 0.2332 g CO_2.

III. 0.2862 g substance gave 0.0961 g H_2O.

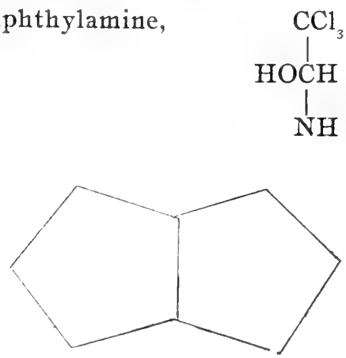
IV. 0.2912 g substance gave 12.2 c.c. nitrogen at 18°C and under a pressure of 758 mm.

	Calculated for $C_{12}H_{10}ONCl_3$	Found I.	II.	II.	IV.
Cl	36.61	36.98			
C	49.58		50.08		
H	3.48			3.52	
N	4.83				4.82

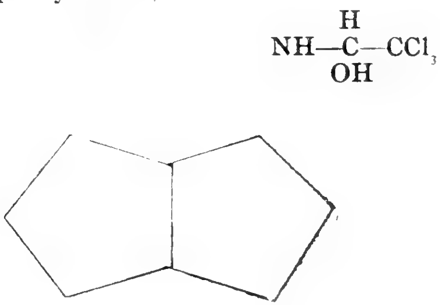
The β—isomer crystallizes in colorless needles and in the mass is light and bulky. It is solnble in ether, benzene, and alcohol but only slightly soluble in ligroin. It melts at 104°C and soon decomposes on exposure to the light.

The constitution of these addition products is represented by the following graphic formulae:

Chloral—α—naphthylamine,



Chloral—β—naphthylamine,



Chapel Hill, N. C.,
Sept. 24, 1906.

JOURNAL

OF THE

ELISHA MITCHELL SCIENTIFIC SOCIETY

DECEMBER, 1906

VOL. XXII NO. 4

PROCEEDINGS OF THE ELISHA MITCHELL SCIENTIFIC SOCIETY.

A business meeting was held on September 27, 1905, for the purpose of electing officers. The election resulted as follows:

H. V. Wilson, *President.*

Archibald Henderson, *Vice-President.*

F. P. Venable, *Corresponding Secretary.*

A. S. Wheeler, *Recording Secretary.*

Editorial Committee: W. C. Coker, Chairman, A. Henderson, J. E. Latta.

The following programs were carried out during the college year, 1905-1906:

161ST MEETING, OCTOBER 17, 1905

Paper Making—*A. S. Wheeler.*

On the Formation of Regenerative Bodies in Sponges When Kept in Confinement—*H. V. Wilson.*

162ND MEETING, JANUARY 23, 1906.

Tropical Notes—*W. C. Coker.*

A Group of Cross Ratios—*A. Henderson.*

Printed January 19, 1907.

163RD MEETING, FEBRUARY 13, 1906.

The Epiploical Appendages—*C. S. Mangum.*
The Cement Gold Ores of South Dakota—*J. H. Pratt.*
Colloidal Solutions—*R. O. E. Davis.*

164TH MEETING, MARCH 13, 1906.

President F. P. Venable addressed the society on "The Progress of Chemical Research in the United States."

165TH MEETING APRIL 10, 1906.

The Panama Canal—*William Cain.*

166TH MEETING MAY 8, 1906.

An Architectural Scheme for the University Buildings—*N. C. Curtis.*
Recent Work in Osmosis—*C. H. Herty.*

BUSINESS MEETING, SEPTEMBER 17, 1906.

The annual business meeting was held in Room 4, in the new Chemical Laboratory. The following officers were elected for the coming year:
C. H. Herty—*President.*
W. C. Coker—*Vice-President.*
F. P. Venable—*Corresponding Secretary.*
A. S. Wheeler—*Recording Secretary.*
Editorial Committee: W. C. Coker, Chairman, A. Henderson, J. E. Latta.

167TH MEETING, OCTOBER 9, 1906.

Geology and Forestry in the Ducktown Region—*Collier Cobb.*

Deforesting of the Ducktown Region by Sulphur Fumes—*Hampden Hill.*

The Electric Smelting of Iron Ores—*C. H. Herty.*

168TH MEETING, NOVEMBER 20, 1906.

Denatured Alcohol—*A. S. Wheeler.*

The Mutual Absorption of Attraction by the Attracting Particles—*J. E. Mills.*

A. S. WHEELER,
Recording Secretary.

MOLECULAR ATTRACTION. VI.

On the Mutual Neutralization of the Attraction by the Attracted Particles and on the Nature of Attractive Forces.

By J. E. Mills.

Introduction. We have in several previous papers* discussed an equation of the form,

$$\frac{L - E_1}{\sqrt[3]{d} - \sqrt[3]{D}} = \text{Constant},$$ (L is heat of vaporization of a liquid, E_1, is the energy spent in overcoming external pressure, d and D are the densities of liquid and vapor respectively). This equation was derived theoretically on the assumption that the attraction between the molecules of a liquid varied inversely as the square of their distance apart and did not vary with the temperature. The equation has now been tested for thirty-three substances over wide ranges of temperature, (usually from near the freezing point of the liquid to the critical temperature), and the evidence in favor of the truth of the equation is exceedingly strong. This evidence will be briefly reviewed later. But admitting the truth of the equation, does it necessarily follow that the assumed law of attraction was the true one? Could it be possible that some other law of attraction operating either by itself, or in connection with other energy changes would give a similar equation? It is with this phase of the question that the present paper is concerned, and we will endeavor to show that the assumptions upon which the equa-

*Jour. Phys. Chem., 6, 209, (1902); 8,383, (1904); 8,593, (1904); 9,402, (1905); 10,1, (1906).

tion is based are correct, and that the equation is correctly deduced. Having given the evidence upon this point we show further that the conclusion may be drawn with considerable certainty that the molecular attraction is mutually absorbed by the attracted particles. Finally our knowledge of the laws of molecular attraction enables us to institute a comparison with other attractive forces and obtain some very suggestive results.

The conclusions to be drawn so closely concern our fundamental ideas of matter that we may be pardoned for briefly calling attention to laws and ideas, more or less generally admitted, upon which the present work is based.

THE FUNDAMENTAL IDEAS SERVING AS A BASIS FOR THE PRESENT WORK.

Our Idea of Matter. Since scientists are somewhat divided in their belief as to the ultimate nature of matter, we would, even though it involves repetition from a previous paper, make clear our own position in this regard, for the question with which we are dealing leads back to a consideration of the nature of mass as we measure it, if not to a consideration of the nature of matter. Because we use the term "molecule", "molecular attraction", and "distance between the molecules", we do not wish to be understood as possessing the idea that a molecule is *necessarily* a little hard sphere or some other particular shape of a piece of "something" extended in space. In the latter part of this paper we have something to say, (by way of speculation suggested by the facts to be considered), regarding the possible ultimate nature of mass. But in the present part of this paper we do not care to consider the nature of matter. We do not care whether it consists wholly of a "something" that possesses the property of extension, or wholly of energy, or is a mixture of the two. The law of gravitation has been shown to hold between certain large masses of a thing commonly called "matter". If later it happens to be proved that

matter, (in the sense of an "extended something"), is not reality and that only energy exists, we do not suppose the proof will greatly affect the calculations of the astronomers, or the position of the heavenly bodies, or their movement in accordance with the law of gravitation. The object of this series of papers is to throw light upon the law of attraction which exists between smaller masses of the same material of which these larger bodies are more conspicuous representatives. Following considerable precedent, we have called these "smaller masses" molecules, a term which conveys to every scientist a group of properties sufficiently clearly defined for the purpose in view. By the expression "distance between the molecules", we mean the distance between their centers of mass—an expression exactly analogous to the distance between two heavenly bodies. The "center of mass" is therefore a mathematical point, determined by the same principles that would be used for large masses. The term "molecular attraction" indicates a force which can be regarded as having its origin at the mathematical point thus determined. We are accordingly entirely free from any assumption as to the size of the particles (molecules), their nature, or the ultimate cause of the force. What we really assume is, that in nature certain forces *act as though they proceeded from mathematical points*, and we clothe these mathematical points with the name "molecule".

The Kinetic Theory of Gases. It is by no means necessary for us to point out how the laws of gases discovered by Boyle and Gay Lussac, and the simple relations connecting the densities of gases, discovered by Gay Lussac, but stated most clearly in the terms of Avogardro's hypothesis, that equal volumes of all gases contain the same number of molecules, are explained by the kinetic theory of gases. Nor how this theory similarly explains Dalton's law for the pressure of mixed gases and Henry's law governing the solution of a gas in a liquid. Nor how the theory lead Clark Maxwell to the discovery of the law governing the viscosity of

gases, and Waterston to the simple relation existing between the two specific heats of a gas. Van der Waals theory also is a fruit of the kinetic theory, and indeed the kinetic theory has been the stimulus and the guide to much of the work upon both liquids and gases. We do not believe that there are many chemists who will object to the acceptance of the kinetic theory of gases as a basis for further work.

According to the kinetic theory of gases we may regard the total energy of a gaseous molecule as being the sum of certain amounts of energy which may be quite clearly differentiated from each other. We would distinguish these energies as follows:

I. The chemical energy, or energy of combination of the atoms constituting the molecules. It can be shown, independently of theory, that the molecule must possess this energy at the absolute zero of temperature,—273°C. (We do not suppose that all motion ceases at this temperature. Just what part of the motion ceases is perhaps even yet a matter of doubt). To prove this proposition we will consider the reaction.

2.016 grams hydrogen (gas) + 16.00 grams oxygen (gas) = 18.016 grams water (liquid).

The amount of heat evolved by this reaction, when taking place at 18°C has been measured by Thomsen and found to be 68420 calories. Now the total amount of heat necessary to raise hydrogen and oxygen from the absolute zero to 18°C can be ascertained from the following data.

	Hydrogen			Oxygen		
Melting point	14.1°		Travers	Below 50°		Travers
Boiling point	20.41		Travers	90.20		Travers
Specific heat of solid	2 3	Cals.	Kopp	0.25	Cals	Kopp
Specific heat of liquid	6.00	"	Estimated Dewar	0.347	"	Alt
Specific heat of gas	3.410	"	Wiedemann	0.2175	"	Regnault
Heat of Fusion	16.0		Estimated Dewar	4.9	"	Estimated
Heat of Vaporization	125.0	"	Dewar	50.92	"	Alt

The specific heat of ice is given as 0.4627 by Regnault and the heat of fusion of ice as 79.9 calories by Smith.

If to the energy added to the substance as specific heat of the solid, liquid, and gas, respectively, there be added the heat of fusion and the heat of vaporization, we will obtain the total heat required to raise the body from the absolute zero of temperature to the chosen temperature, in this case to 18°C. We have therefore for the total energy necessary to raise the temperature from 0° absolute to 18°C for,

2.016 grs. of hydrogen	= 2286 calories.
16.00 grs. of oxygen	= 2015 "
18.016 grs. of water	= 3865 "

The values given are probably maximum values and not very far from the truth except in the case of water, where we think the value would probably be considerably too large, due to the use of the specific heat for ice as found by Regnault between –78° and 0°C as representative of the average specific heat of ice, –273° to 0°. The value of the specific heat, judging from analogy, probably decreases as the temperature is decreased.

It appears therefore that in raising the 2.016 grams of hydrogen and the 16.00 grams of oxygen from the absolute zero to 18°C only 4301 calories of energy were required, while at this temperature 68420 calories were given out when they combined. Since the water formed possesses about 3865 calories of energy, it follows that the hydrogen and oxygen possessed at least 67984 calories of chemical energy at the absolute zero. Further, since only the difference between the chemical energy of the H_2 and O_2 on the one hand and of the H_2O on the other, is ascertained, we cannot make any statement as to the actual amount of chemical energy possessed by the H_2 and O_2 at the absolute zero. We can only say that it is certainly *not less than* 67984 calories. It may be many times more.

It follows from the above that the chemical energy has

been either entirely unaffected by the change in temperature of 291°, or has been affected only in a very minor degree. For a stable chemical body, where the change in temperature is not large, we have little hesitation in saying that the chemical energy, E^c, of the body is a constant.

1. E_c = constant.

We will return later to a further discussion of the chemical energy.

2. The Translational or Kinetic Energy of the Molecule. This energy for any particular molecule is equal to ½ the mass of the molecule multiplied by the square of its velocity. It follows from the well known investigation of Clerk Maxwell that the velocities of the different molecules of a gas vary somewhat, but the variation is confined within rather narrow limits and only very few of the molecules have a velocity greatly above or greatly below the average molecular velocity. This theorem of Maxwell regarding the distribution of velocity among the molecules of a gas has been proved with strictness for the supposition that the molecules act on each other only at the moment of collision. For such a condition, using the constants adopted in former papers, the sum of the translational energy, E_k, of all of the molecules can be represented by,

$$2.\ E_k = \tfrac{3}{2}RT = 2.9817\frac{T}{m}\text{calories,}$$

where T is the absolute temperature, and m is the molecular weight referred to oxygen = 16.00 as standard.

It has never been shown that the translational energy of a molecule, when the molecule is subject to attractive force, can be calculated by this formula and the formula is therefore proven (with assumption of the kinetic theory) only for so-called "perfect" gases.

3. The Internal Energy of a Molecule. Experiments have shown that the specific heat of a gas at constant pressure is nearly a constant over considerable ranges of temperature. The

variation from absolute constancy appears to be due to variations from the gas laws, when the gases examined are far removed from the condition designated as "perfect" gases, and also to certain progressive changes taking place within the molecule as the temperature is raised—the progressive changes finally ending in the decomposition of the molecule. The measurements therefore make it very probable that for a perfect gas, and one that is chemically stable, (that is, one in which the chemical energy does not change with the temperature), the specific heat at constant pressure would be a constant.

But for such gases the law, $PV = RT$, holds true, and consequently, $PdV = RdT$, which for a change of one degree gives, $Pdv = R$. If σ_p and σ_v denote the specific heat at constant pressure and constant volume respectively, we have,

$$3.\quad \sigma_p - \sigma_v = R.$$

If the increase in the translational energy of the molecules of any gas be subtracted from the specific heat at constant volume of the gas, a certain residue remains, (equal to zero for monatomic gases), which we shall consider as being due to a change in the internal energy, E_i, of a molecule. We will have, therefore,

$$4.\quad \sigma_v = \frac{dE_k}{dT} + \frac{dE_i}{dT} = \text{Constant.}$$

True strictly only for a "perfect" gas.

Now from the theory by Waterson,

$$5.\quad \gamma = \frac{\sigma_p}{\sigma_v} = \frac{dE_k + dE_i + R}{dE_k + dE_i}, \ dT \text{ being equal to } 1°\text{C.}$$

Wherefore substituting for R its value, $\tfrac{2}{3} E_k$, and solving,

$$6.\quad E_i = \frac{5/3 - \gamma}{\gamma - 1} E_k = 2.9817 \left[\frac{5/3 - \gamma}{\gamma - 1} \right] \frac{T}{m} \text{ Calories.}$$

The internal energy in a perfect gas is therefore proportional to the translational energy.

The exact function of the internal energy required by a molecule has never been satisfactorily explained, but the fact that it is proportional to the translational energy leads to the belief that the internal energy is a direct consequence of the translational energy It should be understood however, *that equation 6 embodies no assumption whatever regarding the internal energy.* That it is proportional to the translational energy follows necessarily, if the specific heat at constant volume is a constant and if the gas law, $PV = RT$, holds true. Nor will the possibility that this internal energy is merely the rate of change of, (the differential of), the chemical energy with the temperature, in any way affect our conclusion.

The data upon the specific heat of gases cannot be discussed briefly. Much of the data is given and discussed in Meyer's Kinetic Theory of Gases and in Nernst's Theoretische Chemie. Reference must be made to these or similar works for the actual data showing the constancy of the specific heat under the conditions set forth above.

4. The Energy of Position Due to the Attraction between the Molecules.

It is the purpose of this series of papers to show that this potential energy is due to an attractive force emanating from each molecule—that this force varies inversely as the square of the distance apart of the molecules—is mutually neutralized by the attracting particles—and is unaffected by temperature changes. We will later deduce the law governing this energy.

5. The Energy of Volume Due to the External Pressure. This energy, it is evident, is measured simply by the pressure times the volume. Denoting this energy by E_e we have,

7. $E_e = 0.0_4 41833 PV$ calories,

Where P is expressed in millimeters of mercury. The constants used have been given in previous papers.

We can regard a perfect gas as a gas in which there is no

energy due to attraction and therefore the energy of such a gas could be represented thus:—

8. $\Sigma E = E_{Chemical} + E_{Kinetic} + E_{Internal} + E_{External}$.

We can also regard a perfect gas as one in which the molecules are so far removed from each other that their mutual attraction has no appreciable effect in modifying the motions of the particles. Such a gas would still possess potential energy due to the attraction and we would therefore have,

9. $\Sigma E = E_{Chemical} + E_{Kinetic} + E_{Internal} + E_{Attractive} + E_{External}$.

We could differentiate between the chemical energy as being a function of the atoms, the kinetic, internal, and attractive energies, as being a function of the molecule, and the external energy as being a function of the mass. The internal energy may be only the differential of the chemical energy with respect to the temperature, and consequently, be more directly a function of the atoms.

Equations 8 and 9 represent the condition of things in a perfect gas. If we now consider a saturated vapor or a liquid, where the molecules are so close together that the gas laws are not obeyed. it is evident from what has already been said that E_c is, if the body be chemically stable, the same as for that substance when existing as a perfect gas. The value for the external energy can be readily calculated, independently of assumptions, save the first law of thermodynamics. The internal energy, E_i, is, we have seen, proportional to the translational energy, E_k, and it is highly improbable that this proportionality would be destroyed by the nearness of the molecules and their increased mutual attraction. The kinetic energy of the molecules might itself be altered, equation 2 having been proved to hold only for a perfect gas. But where mathematical proof is lacking, experimental evidence has taken its place. Since Van't Hoff showed that for undissociated dissolved substances the osmotic pressure given by a dissolved substance was equal to

the pressure that the dissolved substance would exert were it a gas at that volume and temperature, it has been very probable that the osmotic pressure was due to the same cause as the gas pressure viz:—the motion of the dissolved particles, and therefore, the kinetic energy of the dissolved substance is the same that it would be for a gas under the same conditions of temperature and volume.

The molecules of the dissolved substance could not have an average kinetic energy different from the average kinetic energy of the molecules of the solvent, a fact long ago pointed out by Ostwald*. Therefore it seems probable that equation 2 holds also for liquids.

(The work of Morse and Frazer† shows that the theory of Van't Hoff needs some modification, and the work of Kahlenberg‡ is in evidence against the theory. We would, as regards the work of Kahlenberg, point out that his experiments numbers 53, 59 and 60 show that the dissolved substance was obeying Boyle's law for gases, (as concerns concentrations), and experiment 53 was *performed without stirring*. Also the manometer tube attached to Kahlenberg's osmotic cell, as given by him, was only of 0.5 mm. bore, and consequently, to produce a rise of 50 cms. in his manometor tube only 1/10 of a cubic centimeter of liquid needed to enter the cell. The amount of $LiCl$ leaving the cell was 0.0130 and 0.0267 and of cane sugar 0.1149 and 0.2205 grams and *the osmotic pressure is determined by the relative rate of inflow and outflow*. It seems to us possible, also, that thermometer effects of the cell were not wholly eliminated from influencing the results. We would not therefore, as yet, abandon Van't Hoff's theory and its results as a reason for believing that equation 2 holds also for liquids and that the average kinetic energy of the molecules of a liquid is equal to the

*Solutions, p. 147, 148.

†Amer. Chem. Jour. 34, 1, 1905,

‡Jour. Phys. Chem., 10, 3, 141, (1906).

average kinetic energy of the molecules of its vapor at the same temperature).

Further Traube finds that his "co-volume" for liquids varies as the absolute temperature*.

We give additional evidence bearing on the truth of equation 2 later in this paper.

If it be granted, then, that equation 2 holds also for liquids and for saturated vapors, the energy of a molecule of a vapor differs from the energy of a molecule of a liquid only because of changes in E_a and E_e. The latter change is easily calculated and we can therefore obtain a measure of the former —the energy change due to the attraction.

Expressing the above belief in a different form we may say that the energy necessary to change a liquid into a gas must, then, be spent solely in overcoming the external pressure and in altering the distance apart of the molecules. (Unless the molecule breaks apart also or nears the point of disruption). Denoting the heat of vaporization by L and the energy necessary to overcome the external pressure during the change from liquid to gas by E_e, $L - E_e$ must equal the energy spent in overcoming the molecular attraction.

DERIVATION OF THE EQUATION.

The derivation of the equation expressing the energy due to the molecular force as given in the first paper of this series was not carried out with strictness and we therefore give below a proof which we believe to be mathematically rigorous.

Let v and V represent the volume of the liquid and vapor before and after expansion, and d and D represent the corresponding densities. Let n equal the number of molecules and m the mass of each molecule. Suppose the molecules evenly distributed throughout the space occupied by them.

*Numerous papers Among others: J. Traube, Grundriss d. Phys. Chem., Boltzman, Festschrift (1904). Sammlung Chemischer und Chemisch—technischer Vortraege IV, 255.

Then

$$\sqrt[3]{\frac{v}{n}} \text{ and the } \sqrt[3]{\frac{V}{n}}$$

represent the relative distance apart of the molecules of liquid and vapor respectively.

It is highly improbable that the molecules of a liquid are evenly distributed throughout the space occupied by them But if they are shifted from their ideal position by reason of the attractive force, the particles would gain in kinetic energy exactly so much as they would lose in potential energy. We may therefore, without error, consider them to be shifted back into this ideal position of even distribution, and the fundamental supposition upon which the mathematical work given below is based, is, that the molecules of a liquid and the molecules of its vapor have *per se*, (exclusive of E_a and E_e), the same energy *when they are in this ideal position of even distribution throughout the space occupied by them.*

If this supposition represents truly the condition of the molecular energy, then it is possible to find the law governing the forces which act between the molecules. For we have only to assume the law and deduce the corresponding equation. If the deduced equation fails to agree with the experimental facts then another law could be assumed and the process repeated until the correct supposition had been made.

We will assume that the molecular attraction varies inversely as the square of the distance apart of the molecules and is a mutual property of each pair of molecules. Hence the force

$$= \frac{\mu^2 m^2}{r^2}$$

where μ is the attraction at unit distance on unit mass, and r is the distance apart of the molecules whose mass is represented by m.

If now we consider two molecules whose distance apart is

$$X\sqrt[3]{\frac{v}{n}}$$

before expansion, (vaporization), after expansion their distance apart will be

$$X\sqrt[3]{\frac{V}{n}}$$

and the work done in pulling them apart will be,

$$10.\quad \int_{X\sqrt[3]{\frac{v}{n}}}^{X\sqrt[3]{\frac{V}{n}}} m^2\mu^2\frac{dr}{r^2} = \frac{m^2\mu^2}{X}\left[\frac{1}{\sqrt[3]{\frac{v}{n}}} - \frac{1}{\sqrt[3]{\frac{V}{n}}}\right],$$

where x is an unknown constant. If we in turn consider the work, W_1, done in pulling all of the molecules away from one molecule, and sum up. we will have, similarly,

$$11.\quad W_1 = m^2\mu^2\left[\frac{1}{\sqrt[3]{\frac{v}{n}}} - \frac{1}{\sqrt[3]{\frac{V}{n}}}\right] + \left[\frac{1}{X} + \frac{1}{X_1} + \frac{1}{X_2} + \ldots + \frac{1}{X_{n-2}}\right]$$

If now we take any other molecule and similarly sum up the energy, W_2, required to pull all of the molecules away from it, we have for the work so done,

$$12.\quad W_2 = m^2\mu^2\left[\frac{1}{\sqrt[3]{\frac{v}{n}}} - \frac{1}{\sqrt[3]{\frac{V}{n}}}\right] \times \left[\frac{1}{X'} + \frac{1}{X'_1} + \frac{1}{X'_2} + \ldots\ldots + \frac{1}{X'_{n-2}}\right]$$

By similarly extending the process to the other molecules, each considered in turn as a center, we will obtain a series of similar expressions, n in number. The last factor of each member of the series depends only upon the number of the molecules n,, and is entirely independent of the nature of the

molecules or of the forces. We may, therefore, denote this last factor in the different series by c_1, c_2, c_3, ...c_n,

Summing up the entire n series of equations we will have,

13. $W_1 + W_2 + W_3 + \ldots\ldots + W_n =$

$$m^2\mu^2\left(\frac{1}{\sqrt[3]{\frac{v}{n}}} - \frac{1}{\sqrt[3]{\frac{V}{n}}}\right)\left(c_1 + c_2 + c_3 + \ldots\ldots + c_n\right).$$

The last factor of this equation is a constant if the number of molecules remains the same. Let C represent this constant. We have then for the total work of expansion, W,

14. $$W = m^2\mu^2\left(\frac{1}{\sqrt[3]{\frac{v}{n}}} - \frac{1}{\sqrt[3]{\frac{V}{n}}}\right)C,$$

Equation 14 gives the entire energy required to pull all of the molecules from each other as vaporization proceeds. It must therefore equal the internal heat of vaporization and we have for mass M,

15. $$M(L - E_e), = m^2\mu^2 C\left(\frac{1}{\sqrt[3]{\frac{v}{n}}} - \frac{1}{\sqrt[3]{\frac{V}{n}}}\right).$$

Letting $d = \dfrac{nm}{v}$, $D = \dfrac{nm}{V}$, $M = nm$, we have,

16. $$\frac{M(L - E_e)}{\sqrt[3]{d} - \sqrt[3]{D}} = \frac{M^2\mu^2 C}{n^2\sqrt[3]{m}}$$

or for a constant mass,

17. $$\frac{L - E_e}{\sqrt[3]{d} - \sqrt[3]{D}} = \text{Constant}.$$

The constant of equation 17 we shall call μ'

(In the previous derivation of this equation 17, we assumed, $c_1 = c_2 = c_3 = \ldots\ldots = c_n$, a fact which is experimentally true, but which is contradictory to the law of attraction assumed, if the latter is unmodified. Also we regarded the

entire attraction in each case as proceeding from one molecule and being measured by

$$\frac{\mu m}{r^2}$$

instead of being a mutual property of the two molecules and being measured by

$$\frac{\mu^2 m^2}{r^2},$$

See further below).

EVIDENCE PROVING THE EQUATION.

The evidence proving that

$$\frac{L - E_e}{\sqrt[3]{d} - \sqrt[3]{D}}$$

is equal to a constant, has been given in the second, third and fifth papers of this series. We would only summarize here by saying that thirty-five substances have now been examined, at intervals of 10° *C*, over wide ranges of temperature, extending usually from near the boiling point of the substance to the critical temperature. Within ten degrees of the critical temperature there is an apparent divergence due to causes shown. Omitting these observations out of 435 remaining observations on 26 different substances only thirty differed from the mean value of the constant for that substance by more than two per cent and only four of these thirty by more than five per cent. The reason for most of these divergences is suspected and investigation will be made of them later. Of the remaining substances, CO_2, N_2O, and SO_2, gave probably as good agreement as the data permitted. Five other substances were associated and showed, as was to be expected, a divergence from a constant value for the constant, and $SnCl_4$ likewise showed a divergence. The evidence in favor of the truth of the equation is therefore

most convincing. That the equation itself is true can hardly be doubted when the evidence is examined. But does it follow that the assumed law of attraction is the true one?

THE NEUTRALIZATION OF THE ATTRACTION BY THE ATTRACTED PARTICLES.

The answer to this question is of great interest. For if the attraction between the molecules varies inversely as the square of their distance apart, then the resultant attraction caused by the large number of molecules must apparently increase as we proceed outward from an interior centrally chosen particle. This follows because the number of molecules increases as the cube of the distance from the centrally chosen molecule, whereas the attraction varies only inversely as the square of that distance. Hence the resultant attraction of any mass upon a particle exterior to the mass, when regarded as proceeding from the center of that mass, must vary as the mass.

The molecular sphere of action could not, therefore, be small but would embrace the entire mass taken. Now we regard the evidence that the molecular sphere of action is small, as being beyond dispute and will not attempt here to give the evidence for this idea. But we will point out that the derived equation 16, itself bears evidence that we have in previous papers been considering only one phase of the question. The equation was given in the form,

$$\frac{M(L - E_e)}{\sqrt[3]{d} - \sqrt[3]{D}} = \frac{M^2\mu^2 C}{n^2\sqrt[3]{m}},$$

where M represents the mass of liquid taken for the vaporization. Now in the test of the equation, the number of molecules was assumed constant, and this was justifiable, since it would be experimentally possible to have them constant. But should they vary, we know experimentally that the left hand side of the equation varies simply with the mass taken,

While the right hand side of the equation varies, not alone because of the variation thus caused in M, but also because of the variation caused at the same time in C and in n. Since C is function of n, it might be supposed, as one occurs in the numerator and the other in the denominator, that the variation would cancel. We have not succeeded in summing up the $n(n-1)$ terms represented by the C of equation 16, but the relation of C to n can be obtained by attacking the problem somewhat differently,

Helmholtz in 1854 investigated the amount of energy that would be given out by the contraction of the sun in order to determine if the energy continually radiated from that body could be thus obtained. In this investigation he assumed that the particles of which the sun was composed were at the same temperature before as after the contraction, the excess of energy having been radiated off into space. He also assumed that the force acting between the particles of the sun's mass obeyed the Newtonian law of gravitation. Hence the investigation was essentially the same as the one above carried out. But Helmholtz made possible a better mathematical treatment by the assumption that the sun was homogeneous in density. We take the liberty of giving below the investigation as given by Helmholtz*.

"Consider a homogeneous gaseous sphere whose radius is R_0 and density σ. Let M_0 represent its mass. Let dm represent an element of mass taken anywhere in the interior or at the surface of the sphere. Let R be the distance of dm from the center of the sphere, and let M represent the mass of the sphere whose radius is R. The element of mass in polar coordinates is,

18. $dM = \sigma R^2 \cos\phi \, d\phi \, d\theta \, dR.$

The element is subject to the attraction of the whole sphere within it. As can shown, the attraction of the spherical shell outside of it balances in opposite directions so that

*Celestial Mechanics. Moulton, p. 58.

it need not be considered in discussing the forces acting upon dM. Every element in the infinitesimal shell whose radius is R is attracted towards the center by a force equal to that acting on dM: therefore the whole shell may be treated at once. Let dM_s represent the mass of the elementary shell whose radius is R. It is found by integrating 18 with respect to θ and ϕ. Thus,

$$19. \quad dM_s = \sigma R^2 dR \int_0^{2\pi} \left\{ \int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} cos\phi d\phi \right\} d\theta = 4\pi\sigma R^2 dR.$$

The force to which dM_s is subjected is $-\dfrac{K^2 M dM_s}{R^2}$.

The element of work done in moving dM_s through the element of distance dR is

$$dW_s = -dM_s \frac{K^2 M}{R^2} dR.$$

The work done in moving the shell from the distance CR to R is the integral of this expression between the limits CR and R, or

$$W_s = -dM_s K^2 M \int_{CR}^{R} \frac{dR}{R^2} = \frac{dM_s K^2 M}{R}\left(\frac{C - 1}{C}\right).$$

But $M = \frac{4}{3}\pi\sigma R^3$; hence substituting the value of dM_s from equation 19 and representing the work done on the elementary shell by $W_s = dW$, it follows that

$$dW = \frac{16}{3}\pi^2\sigma^2 K^2\left(\frac{C - 1}{C}\right)R^4 dR.$$

The integral of the expression from O to R_0 gives the total amount of work done in the contraction of the homogeneous sphere from radius CR_0 to R_0. That is

$$20.\quad W = \tfrac{16}{3}\pi^2\sigma^2 K^2\left(\frac{C-1}{C}\right)\int_0^{R_0} R^4 dR = \tfrac{16}{15}\pi^2\sigma^2 K^2\left(\frac{C-1}{C}\right)R_0^5$$

which may be written

$$21.\quad W = \tfrac{3}{5}K^2 M_0^2\left(\frac{1}{R_0} - \frac{1}{CR_0}\right)$$

Now if the contraction takes place between the limits

$$\sqrt[3]{\frac{3v}{4\pi}} \text{ and } \sqrt[3]{\frac{3V}{4\pi}}$$

we have for the work done,

$$22.\quad W = \tfrac{3}{5}K^2 M_0^2\left(\frac{1}{\sqrt[3]{\frac{3v}{4\pi}}} - \frac{1}{\sqrt[3]{\frac{3V}{4\pi}}}\right) =$$

$$0.9682 K^2 M^{5/3}(\sqrt[3]{d} - \sqrt[3]{D})$$

Comparing this expression with equation 14 we have only to replace the attraction at unit distance between the elements of mass, by the molecular attraction at unit distance and observe that

$$C = 0.9682 n^{5/3}$$

if the mass were of uniform density throughout. We cannot see how the transformation from a sphere of uniform density to one of uniformly distributed particles could effect any change in the energy relations involved. We would therefore write:

$$23.\quad \frac{M(L - E_e)}{\sqrt[3]{d} - \sqrt[3]{D}} = 0.9682 \mu^2 M^{5/3}$$

So long as a constant mass is taken the equation will reduce to the form,

$$\frac{L - E_e}{\sqrt[3]{d} - \sqrt[3]{D}} = \text{constant.}$$

If, however, the mass be varied, the equation informs us that the work done should vary as the five-thirds power of

the mass. It should require three and two-tenths times as much heat to vaporize two grams of a liquid as to vaporize one gram. As a matter of fact, we know that it only requires twice as much heat to vaporize two grams as to vaporize one gram. How is this discrepancy to be explained?

In attacking this problem we would call attention to the fact that the equation,

$$\frac{L-E_e}{\sqrt[3]{d}-\sqrt[3]{D}} = \text{constant}.$$

does correctly represent the variation of the energy change caused by the attraction with the distance, as is shown by the evidence accumulated in previous papers and as indicated in the brief summary above. It seems reasonable therefore to suspect the cause of the variation to be due to the numerator of the function representing the law of the force,

$$f = \frac{\mu^2 m^2}{d^2}$$

and not the denominator.

If now, we study the action of other attractive forces, such as magnetic forces, we find an explanation of the apparent contradiction at once suggested. The magnetic force varies directly as the product of the strengths of the poles and inversely as the square of their distance apart. But the interposition of a piece of sheet iron into the magnetic field between the magnet and the attracted particles serves to cut off the attraction, more or less completely, from the formerly attracted particles. Whether we look upon the interposed sheet of iron as actually absorbing the force, or as merely changing the direction of the lines of force, is not essential, the result at least is clear—particles beyond the interposed sheet are subject to less attraction because of the interposition. So if we were to imagine a magnetized particle of iron surrounded by other particles of iron, evenly distributed, and

similarly magnetized, the attraction would vary inversely as the square of the distance apart of the particles and yet the sphere of action of any particular particle would be small, due to the shielding action of the particles. And it seems to us that we may have here an exact representation of molecular attraction.

There is much indirect evidence to support such a conclusion. The attraction designated as chemical affinity is mutually absorbed by the combining bodies. At least the force is canceled by the combination so far as its effect on other particles is concerned. The combination of one sodium atom with one chlorine atom certainly serves to shield other bodies from the attractions of both the sodium and the chlorine, rendering them in a large measure chemically inert. And this action is commonly represented by saying that the "bond" of the sodium is neutralized or saturated by the "bond" of the chlorine. As we have just mentioned, a similar effect happens with magnetic forces. If electrical forces be considered we find again the same to be true. And if we undertake to consider yet more closely the nature of attractions in general, is it not apparent, that, whatever the ultimate nature of the attractive force may be, yet it cannot be infinitely multiplied? That just so much force must emanate from each particle, and if this force is exerted on one particle there will be somewhat less of the force remaining for the remaining particles. *Is it not unreasonable to suppose that a particle could exert its attractive pull upon one thousand, or one million, or one hundred million, particles and yet always have just as much of its force remaining to exert on other particles brought within the same distance?* We are not confusing force and energy. Can a man by means of a rope exert the same pull on each of twenty other men that he could exert on one man? Does not each stress exerted lessen by just so much the power of a man to exert a similar pull upon other things? Can we multiply, *ad infinitum*, any force about whose real nature we know anything at all, merely by the introduction

of further objects upon which the force can be exerted? Is there any form of wave motion, vibration or emanation, known, whose effect can be thus infinitely increased?

Look at the question from the other side. Is it reasonable, that the introduction of particles of matter into the space surrounding a molecule chould be absolutely without influence on the emanation which proceeds from the molecule and gives rise to the phenomena of attraction? And that this filling in of the space surrounding a molecule with other particles of matter (or centers of energy, if you choose) should be able to continue, ad infinitum, without disturbing the attractive radiation proceeding from the body?

Moreover the mere fact that all of the attractive forces, whose law of variation with the distance we know; do vary inversely as the square of the distance from the attracting body, *is evidence, that the attractive force is in each case some sort of wave motion or emanation whose intensity decreases directly in proportion to the increase in the surface of the wave or emanation front*, since and because this surface varies as the square of its distance from the origin. Can we, on the one hand, believe that the intensity of these forces thus decreases, and on the other, consider them unmodified by the presence of matter and capable of infinite multiplication by the introduction of additional matter into an infinite range of action?

In place of such a conception we would introduce the idea *that the attractive forces, whatever their nature, whether chemical, molecular, magnetic, electrical, or gravitational, which proceed from a particle, are definite in amount. If this attraction is exerted upon another particle the amount of the attraction remaining to be exerted upon other particles is diminished by an exactly equivalent amount.*

We are of course aware that no such diminution of the attraction is supposed, or is supposed possible, for gravitational forces. That certain facts have led to the belief, difficult of conception as it may be, that this force attracts every particle of matter in the universe exactly as if no other

particle of matter were present. And that these facts would at once be urged as contradicting the above statement as to the attractive forces. We would answer by calling attention in detail to the evidence in favor of the above idea.

FURTHER EVIDENCE REGARDING THE MOLECULAR ATTRACTION

As regards the molecular attraction the conclusions cited above have been based on evidence which, for purposes of examination, may conveniently be divided into five steps as follows:—

1. The equality of the energy *per se* of the molecules of a liquid and of the molecules of its vapor at the same temperature. That is $E_c + E_k + E_i$ for a molecule of a liquid equals $E_c + E_k + E_i$ for a molecule of its vapor, the difference in their energy consisting of a difference in E_a and E_e.

2. The assumption that the attraction was a mutual property of each pair of molecules, varying directly as the mass of the molecules, (so long as the same chemical body is considered), and inversely as the square of the distance apart of the molecules. Later modified by 5 below.

3. The derivation of an equation expressing the energy relations necessitated by the above two conditions.

4. The experimental evidence deduced in favor of the equation.

5. The facts leading to the supposition that the molecular attraction is mutually absorbed by the attracting particles.

Examining these steps separately, let us see which are open to doubt. Considering first the fourth—the experimental evidence in favor of the equation—we would here add nothing new. But we would put one portion of the evidence in a more striking form. We will use the equation derived by Helmholtz in 1854 as expressing the energy given out by

the contraction of the sun, to calculate the energy given out by the contraction of isopentane from a gas to a liquid. The equation of Helmholtz has been given, equation 22, and is, for a change of volume corresponding to a change of density from D to d,

22. $W = 0.9682 K^2 M^{5/3}(\sqrt[3]{d} - \sqrt[3]{D})$

To apply the equation to one gram of isopentane we have only to substitute for the constant in the above equation, the value for this constant that we have already found, 105.4. The equation then becomes,

24. $W = 105.4(\sqrt[3]{d} - \sqrt[3]{D})$.

We give below in Table 1 the data and the results. The values given by equation 24 are in the column headed W. Under the heading $L - E_e$ we give the values of the internal heat of vaporization as actually determined from Young's measurements. It is inconceivable to us that the agreement between W and $L - E_e$ could be accidental.

TABLE 1

Temperature	Density of liquid	Density of vapor	$\sqrt[3]{d} - \sqrt[3]{D}$	U	$L-E_e$
0° C.	.6382	.001090	.7585	79.9	81.3
20	6196	.002358	.7194	75.8	75.2
40	.5988	.004480	.6781	71.5	70.7
60	.5769	.007819	.6340	66.8	66.4
80	5540	.01284	.5871	61.9	61.8
100	.5278	.02022	.5357	56.4	56.7
120	.4991	.03106	.4788	50.5	50.9
140	.4642	.04728	.4127	43.5	44.0
160	.4206	.07289	.3316	34.9	35.4
180	.3498	.1258	.2035	21.4	21.0
185	3142	.1574	.1399	14.7	14.0
187	.2857	.1833	.0905	9.5	8.9
187.4	.2761	.1951	.0712	7.5	6.9
187.8	.2343	.2343	0.0	0.0	0.0

The formula used by Helmholtz to represent the contraction of the sun does represent the contraction of isopentane from the gaseous to the liquid condition. And not only isopentane but essentially as well all of the non-associated substances ex-

amined by us. *For we have already published* similar comparisons for all of these substances*, the only difference being that we added to the energy given out by the contraction, the value of the energy due to the action of the external pressure, and thus obtained the heat of vaporization. We have here republished the results for isopentane as coming from Helmholtz' formula only to emphasize the statement that we have not gone beyond the facts when we declare that, *as regards variation with the distance, the law of molecular attraction is identically the same as the law of gravitation, and precisely the same formula is applicable to both.*

The formula is,

$$25. \quad E_a = \mu'(\sqrt[3]{d} - \sqrt[3]{D}).$$

where μ' has the meaning assigned previously in this and earlier papers.

As regards the third step mentioned above—the derivation of the equation—we can detect no flaw in the proof given by the author, or the proof given by Helmholtz, the basis of the mathematics as expressed in steps 1 and 2 being granted.

As regards the second step—the assumption of the law of the attraction—the fact that a true equation was deduced, entirely theoretically, from the assumption, is the surest evidence that the assumed law was the true one. One point remains to be examined here. Could any other law of attraction have produced the same equation, or one equally in accord with the facts?

To satisfy ourselves upon this point we have in a similar manner deduced the corresponding equations on the assumption that the attraction varied as the third, the fourth, the fifth, and the sixth, powers of the distance between the molecules. These equations would take the form:—

For the inverse third power of the distance,

*See third paper of this series, Tables 1 to 21, and fifth paper, Tables 15 to 24.

26. $$\frac{M(L - E_e)}{d^{2/3} - D^{2/3}} = 0.4841\mu^2 M^{4/3} = \text{Constant for a constant}$$

mass.

For the inverse fourth power of the distance,

27. $$\frac{M(L - E_e)}{d - D} = 0.3227\mu^2 M = \text{Constant for a constant}$$

mass.

For the inverse fifth power of the distance,

28. $$\frac{M(L - E_e)}{d^{4/3} - D^{4/3}} = 0.2420\mu^2 M^{2/3} = \text{Constant for a constant}$$

mass.

For the inverse sixth power of the distance,

29. $$\frac{M(L - E_e)}{d^{5/3} - D^{5/3}} = 0.1936\mu^2 M^{1/3} = \text{Constant for a constant}$$

mass.

Applying these equations to isopentane, the constant given by equation 26 is shown in the column headed $\frac{1}{r^3}$ the constant given by equation 27 in the column headed $\frac{1}{r^4}$ etc. The values at the critical temperature, 187.8°C, were obtained by substituting for $L - E_e$ its value,

$$.0_4 31833\left(V - v\right)\left(T\frac{dP}{dT} - P\right),$$

and getting the limit of the resulting equation where V was eqaul to v. The resulting equations are,

For the limit of equation 26,

30. $$\text{Constant} = .0_4 477\, V^{5/3}\left(\frac{dP}{dT}T - P\right)$$

For the limit of equation 27,

$$31.\quad \text{Constant} = .0_4 31833\, V^{8/3}\left(\frac{dP}{dT}T - P\right),$$

For the limit of equation 28,

$$32.\quad \text{Constant} = .0_4 239\, V^{7/3}\left(\frac{dP}{dT}T - P\right),$$

For the limit of equation 29,

$$33.\quad \text{Constant} = .0_4 191\, V^{8/3}\left(\frac{dP}{dT}T - P\right),$$

The critical temperature is 187.8°C, the critical pressure is 25020 millimeters of mercury, the critical volume is 4.268, and the $\frac{dP}{dT}$ at the critical temperature is 406, from the measurements by Dr. Sydney Young.

It will be seen that when the equation is deduced on the assumption that the attraction varies inversely as the square of the distance apart of the molecules *a constant is obtained, and on no other supposition does the corresponding equation give a constant.* It is evident therefore that *no simple change in the assumption as to the variation of the attraction with the distance will serve to explain the fact that the heat of vaporization does vary proportionately to the mass taken.*

TABLE 2—ISOPENTANE.

Temperature	$L - E_e$	d	D	$\frac{1}{r^2}$	$\frac{1}{r^3}$	$\frac{1}{r^4}$	$\frac{1}{r^5}$	$\frac{1}{r^6}$
0°C.	81.35	.6392	.001090	107.2	111.2	127.5	147.8	171.5
50	68 62	.5881	.005967	104.5	102.6	117.9	139.6	166.3
100	56.67	.5278	.02022	105 8	97 9	111.6	134 6	165.1
150	40.13	.4445	.05834	106.9	92.9	104.0	126.7	160.5
180	21.04	.3498	.1258	103.4	85.7	93.9	114.7	148.1
187.8	0.0	.2344	.2344	107 2	86.9	94.0	114 4	148.3

The law of the attraction assumed, seems, therefore, to be the only assumption that will give an equation in accord with the facts.

As regards now the first step—the equality of the energy *per se* of a molecule of a liquid and of a molecule of its vapor —we have already stated in outline the facts which led us to that belief. This first step is the most fundamental and important step in our work and is perhaps the most open to doubt. The fact that using this belief as a basis we derived an equation that appears to be true, is, perhaps, again the best evidence that the belief, expresses, at least partly, the truth. But only in part, for in attempting to derive a direct method for testing this belief we find that it will require some modification, An account of this work could not be introduced within the limits of this paper and we hope shortly to publish this investigation in a separate article. Recognizing the doubt, we would state that any errors introduced by our statement have undoubtedly canceled, since one is certainly able to calculate the energy given out by the contraction of vapor into a liquid from the same formula used to calculate the energy given out by the contraction of the sun.

As regards now the fifth step—the conclusion that the molecular attraction is mutually absorbed or canceled by the attracting particles—we have only to say here that the conclusion is necessitated by the four previous steps and the further well known facts, that the molecular sphere of action is small, and that the heat of vaporization of a liquid is proportional to the mass of the liquid taken for evaporation.

THE NATURE OF THE ATTRACTIVE FORCES.

We would now return to a consideration of the idea proposed on page 119 of this paper, *that the attractive forces, whatever their nature, whether chemical, molecular, magnetic electrical, or gravitational, which proceed from a particle are definite in amount. If this attraction is exerted upon another particle the amount of the attraction remaining to be exerted*

upon other particles is diminished by an exactly equivalent amount.

We shall call attention to what is actually known as to the action of attractive forces by the following table.

Force	Medium of propogation	Effect of temperature	Is the attraction neutralized?	Is the attraction directive?	Law of distance	Numerator factor of force.
Chemical	Ether	No effect	Neutralized	Yes	?	Nature of atom × Nature of atom
Molecular	Ether	No effect	Neutralized	?	$\frac{1}{d^2}$	Nature of molecule × Nature of molecule
Magnetic	Ether	?	Neutralized	Yes	$\frac{1}{d^2}$	Strength of pole × Strength of pole
Electrical	Ether	?	Neutralized	Yes	$\frac{1}{d^2}$	Charge × Charge
Gravitational	Ether	No effect	Not neutralized	No	$\frac{1}{d^2}$	Mass × Mass

The general resemblance between these forces is so striking, we think, as to warrant a very serious consideration of any idea which leads to the belief that all of the forces do not follow the same law. Are they not perhaps all, in fact, one and the same force?

Considering the chemical force of attraction, the fact that this force does vary as some function of the distances apart of the atoms concerned has, we think, been already shown by the work of Richards* and Traube†. The latter says, "*Wie von mir zuerst festgestellt wurde, ist der Raum eines Atoms keine Konstante, sondern andert sich von Stoff zu Stoff und ist um so kleiner, je grosser die Affinitat des betreffenden Atomes zu den Atomen ist, mit welchen es in unmittelbarer Verbindung steht. Die Kontraktion der Atome ist daher ein unmittelbares Mass der Affinitat.*" Concerning Traube's claim to priority in this discovery see remark by Richards‡. While we prefer not to accept the conclusion of these investigators that the

**Proc. Amer. Acad, of Arts and Sciences*, XXXVII, 1; XXXVII, 15; XXXVIII, 7; XXXIX, 23.

†*Zeitschrift fur Anorganische Chemie*, 40, 380 (1904).

‡*Proc. Amer. Acad. of Arts and Sciences*, XXXIX, 23, p. 583.

atoms themselves suffer a contraction we cannot doubt from the evidence that they have brought forward that the chemical attraction between atoms is one of the deciding factors as to the distance apart of these atoms when combined into a molecule. That is to say, the distance apart of the atoms is some function of the chemical affinity. The problem is as yet too complicated to permit of finding the law of the attraction, and at present we must limit ourselves to the statement that the inverse square law of the distance is possible also with this force. When Newton discovered the law of gravitation others at once seized upon that law as a possible explanation of chemical affinity. Newton himself showed that the chemical attraction decreased more rapidly with the distance than was required by the inverse square law. But if the chemical attraction is mutually absorbed or canceled by the attracting particles, then it again becomes possible that the force itself varies inversely as the square of the distance from any particular atom, itself alone considered. Moreover we know that this mutual absorption of the chemical attraction does take place.

We have made the statement that temperature has no effect upon chemical affinity. We have shown as a reason for this statement that 2.016 grams of H_2 and 16.00 grams of O_2 at the absolute zero possess at least 67984 calories of chemical energy, while the total energy necessary to raise the H_2 and the O_2 from the absolute zero to 19°C is only 4301 calories. Now of this 4301 calories we can account for all but about 165 calories as necessitated by the changes in E_i, E_a and E_e. The details of this calculation will be given in the subsequent paper referred to above. At present we give the result only, as indicating the minute influence that temperature has upon chemical affinity. It is possible that E_i is really the differential of the chemical energy. But even if this be true, it may more reasonably be referred to a slight alteration in the distance apart of the atoms composing the molecule, than to a real alteration of the chemical affinity.

In what form can the enormous amount of energy possessed by the hydrogen and oxygen at the absolute zero exist? Clausius has shown* that no system of particles could exist in stable equilibrium if all of the energy possessed by those particles was present as kinetic energy. Nor could all of the energy exist as potential energy. The energy must be partly kinetic and party potential Now it can be shown that when two particles exist under a mutual attraction varying inversely as the square of the distance apart of the particles, that the system composed of these two particles, assumes the most stable equilibrium when one half of the total energy is kinetic and one half is potential. We cannot but believe it probable, that in a system of particles a similar distribution of energy would take place. The enormous amount of chemical energy that is existent at the absolute zero of temperature must, it seems to us, be present, one half as potential and one half as kinetic energy. That is to say, the hydrogen atoms and oxygen atoms at the absolute zero would revolve in pairs around a common center of gravity with enormous velocity, held in their orbits by the chemical attraction. This conception seems to us quite sufficient to explain the repulsive tendency referred to by Richards in his fourth paper above cited. We shall deal with this subject more fully later. We would only remark that the above conception of the mechanism of chemical affinity introduces no new assumption, save that the attraction obeys the inverse square law. This being true the other results follow if the principles underlying mechanics be true.

Our statement concerning the magnetic and electrical forces, not being the subject of dispute, may be passed over without comment.

As regards the gravitational force we meet the first and only exceptions to a complete similarity between the forces. The gravitational attraction is supposed not to be absorbed or neutralized by the attracting particles.

*See Myer—Kinetic Theory of Gases, p 344.

The questions involving the nature and laws of the attractive forces cannot, we are well aware, be settled by any appeal to our minds as to the relative difficulty or ease of the conception, But on the other hand such an appeal is *not without value.* If in the last analysis the testimony of consciousness cannot be trusted we had just as well give up the search for truth. We cannot hope to attain to any absolute knowledge or full conception of any of the more elementary ideas such as time, space, matter, or motion. But we may attain to a partial knowledge of these ideas, and this partial knowledge, we trust, may represent the reality truly, so far as it represents it at all. And in attempting to attain this partial knowlege, if one goes directly contrary to the testimony of one's mind as to the possibility or impossibility of a conception one should not forget that the process of denying the truth of the testimony of conciousness once begun, can be as legitimately extended to an absolute agnosticism, must be so extended, if one is consistent. One can refuse to examine the foundations for a house but one cannot undermine the foundations and yet continue to build the house. We do not believe therefore, that the difficulties in the conception of the action of gravitational forces can longer be be passed over as constituting no objection to the present statement of the law. Since Newton in 1682 deduced the law, all of the attempts—and they have been numerous—to formulate a sufficient cause for the law, have completely failed. The attempts have ended not only in failure to formulate a cause for the law, but in emphasizing, most distinctly, the difficulty of forming such conceptions at all.

May not the real cause of the trouble lie in the fact that scientists have been trying to explain how a force can be infinitely multiplied and absolutely unaffected by intervening matter, when force with such properties has really no existence?The line of apsides of mercury's orbit has a slight motion unaccounted for by the law of gravitation. Dr. Asaph Hall pointed out that the observations could be statisfied by chang-

ing the law of gravitation by very slightly increasing the exponent of the distance factor. May not this slight divergency, explained as an *increase* in the exponent of the denominator, be explained rather by a *decrease* in the numerator, due to a neutralization of the attraction by the attracted particles. The planets are but dots in space, and the distortion of the field of force by the attraction which they would neutralize would be extremely small.

It will be further urged that we have no evidence of any shielding action in the case of gravitational forces and that, besides, gravitation is proportional to mass and not to surface in any way. In reply we would point out that we are dealing with a very fundamental queston, and that we have, as yet, no explanation of mass. Mass is best represented perhaps by the term "inertia", but the question is what is "inertia"? Why has a molecule of lead more inertia than a molecule of aluminum? We have not, so far as the author knows, one iota of evidence, save in the suggestiveness of the periodic table of the chemical elements, that there is really more of the "ultimate material" in the molecule of lead than in the molecule of aluminum. For anything *we know* to the contrary, mass might be created at the same time as the attraction, a sort of action and reaction due to the same cause. And why this suggestion?

Because if one attempts to consider what changes must be made in the numerator factor of the forces in order to derive a common expression for all of the attractive forces, one starts with the broad idea that the force is measured by the effect which it produces. In producing this effect an opposite and equal effect must be produced on the force itself. This is according to Newton's third law of motion. Any other supposition would mean that the forces could be increased indefinitely. Force is transference of energy. We have no law as to the conservation of force but we have a law as to the conservation of energy, The amount of energy in the universe is constant. In a given time a constant amount of

energy could not produce an infinite amount of force. But this production of an infinite, inexhaustible force is exactly what the law of gravitation necessitates, if it expresses the entire truth. We repeat *that one cannot believe that one particle of matter in the universe can attract every other particle of matter in the universe and itself suffer no diminuation in its power to attract yet other particles of matter and hold also that the law of the conservation of energy is true. For these two beliefs necessitate that a constant energy, in a given time should be able to produce an infinite force, and this is impossible.* We reach therefore the conclusion that the attractive force given out by a particle in a given time is definite in amount. If therefore a portion of this attraction is expended upon one particle there remains exactly an equivalent amount less to be expended on the remaining particles. *Consequently the attraction can be measured by the amount of the neutralized force.* This deduction we claim to be founded on the first law of thermodynamics, the conservation of energy. Now the amount of attractive force which can be neutralized will vary inversely as the square of the distance apart of the particles, because the surface front of the attractive wave of force increases as the square of the distance apart of the particles and its intensity must correspondingly diminish, since the force cannot be indefinitely multiplied. We can therefore write, attractive forces are measured by,

$$\frac{\left\{\begin{array}{c}\textit{amount of attraction neu-}\\\textit{tralized at unit distance}\end{array}\right\} \times \left\{\begin{array}{c}\textit{amount of attraction neu-}\\\textit{tralized at unit distance}\end{array}\right\}}{d^2}$$

Examining the numerator of the above fraction, there appears nothing improbable as regards its application as a general expression to take the place of the first four forces given in the table,—chemical, molecular, magnetic, and electrical. As regards gravitational force it makes mass proportional to the amount of attraction absorbed at unit distance. Is this idea necessarily wrong?

We doubt if the idea is necessarily opposed to established

astronomical data. We might suggest that one reason why no shielding action had been detected among the heavenly bodies was because the mass really did vary with the amount of the shielding and exactly canceled the effect produced. Whether the idea is supported by molecular phenomena is more a subject of doubt. It might possibly explain the increased specific heat of a solid and liquid as compared with the corresponding vapor. We will return to this point in a later paper.

Chemical, magnetic, and electrical forces show decided evidence of directive action. We distinguish, moreover, positive and negative electricity, positive and negative poles of a magnet, and positive and negative elements, as indicating some difference in the kind of attractive force which they exert. As evidence of variation in the intensity of the molecular forces with their spatial relation around the molecule, might be cited the phenomena of crystalline form, of water of crystallization and molecular combinations in general, and also those cases where a liquid appears to show a definite and symmetrical structure. The evidence is not convincing, nor is there evidence indicating positive and negative molecular attraction. With gravitational forces similarly, there is no evidence showing directive, or positive and negative tendencies, unless the earth's magnetic field should be such an evidence.

The exceedingly close relationship between the electrical and chemical forces have often suggested their identity. The close relationship between electrical and magnetic forces is also recognized. There is also some evidence that molecular attraction is closely connected with electrical phenomena. Thus it has been pointed out by Abegg that liquids which cause dissociation are themselves most associated. We would note further a correspondence between the amount of dissociation produced by a liquid on a dissolved substance and the size of the molecular attraction μ', as obtained by us. Perhaps it is also not without significance that the metals are

the best conductors of electricity, are monatomic, and have a very great cohesion.

The amount of the molecular attraction, and the greater or less interpenetration of the molecular attraction among other molecules before it is neutralized, may, it seems to us, be the determining factor in the elasticity, ductility, malleability, brittleness, and hardness of substances in general, and of metals more particularly.

Our knowledge at present, is hardly sufficient to warrant speculation regarding the ultimate cause and nature of the attractive forces. They may be one and the same force,—the molecular attraction being the unneutralized portion of the chemical attraction, magnetic attraction being a manifestation of the latter, and electricity closely connected with the former. Gravitation would be the unneutralized portion of the molecular attraction. We consider it possible that the attractive forces are one and the same force manifested under different conditions.. We consider it likely that all of the forces are produced by some interaction between matter and ether. We consider it highly probable that the forces obey the same law whether their ultimate cause and identity be the same or not. We hope to develop the subject further in later papers.

Summary. 1. The evidence that the molecular attraction varies inversely as the square of the distance apart of the molecules, and does not vary with the temperature, is reviewed and strengthened.

2. It is pointed out that the molecular attraction must be neutralized by the attracting molecules.

3. It is shown that the equation deduced by Helmholtz in 1854, to represent the energy given out by the contraction of the sun will, by changing the constant, represent accurately the energy given out by isopentane and other substances in changing from a saturated vapor to a liquid.

4. It is shown that a large amount of chemical energy is possessed by hydrogen and oxygen at the absolute zero, and

that this energy is probably existent half as potential, half as kinetic, energy.

5. It is shown that chemical attraction is probably unaffected by temperature.

6. The idea is introduced that the attractive forces, whatever their nature, whether chemical, molecular, magnetic, electrical, or gravitational, which proceed from a particle, are definite in amount. If this attraction is exerted upon another particle the amount of the attraction remaining to be exerted upon other particles is diminished by an exactly equivalent amount.

7. The laws governing attractive forces are compared and it is suggested that all of the forces really obey the same law, viz.—the attractive forces are measured by the amount of the attraction neutralized, which is

$$\frac{\left\{\begin{array}{c}\textit{amount of attraction neu-}\\ \textit{tralized at unit distance}\end{array}\right\} \times \left\{\begin{array}{c}\textit{amount of attraction neu-}\\ \textit{tralized at unit distance}\end{array}\right\}}{d^2}$$

8. The idea that the gravitational attraction of a particle could remain undiminished regardless of the amount of the attraction exerted upon other particles is shown to be contrary to the law of the conservation of energy.

Chemical Laboratory, University of North Carolina,
December 10, 1906.

JOURNAL

OF THE

Elisha Mitchell Scientific Society

VOL. XXIII
1907

PUBLISHED BY THE UNIVERSITY
CHAPEL HILL, N. C.

[illegible]

JOURNAL

OF THE

Elisha Mitchell Scientific Society

CONTENTS

VOL. XXIII.

1907.

JOURNAL

OF THE

ELISHA MITCHELL SCIENTIFIC SOCIETY

MAY, 1907

VOL. XXIII NO. 1

THE FOUNDATIONS OF GEOMETRY.

BY ARCHIBALD HENDERSON, PH.D.

The study of the historical development of mathematics, and in particular the study of geometry, leads one to the conclusion that the great roles in the drama of science have been played by two inter-related, yet widely differing, forces—intuition and logic. Huxley once laughingly said of Herbert Spencer that his idea of tragedy was a deduction killed by a fact. Some of the greatest parts in the drama of science have been played by intuition; but that drama becomes a tragedy when intuitional prevision is annihilated by the inexorable irony of fact. The most epoch-making discoveries find their origin in the fortunate conjunction of intuition and experience. And the whole history of science is the history of the struggle of man's intuition, fortified by experience, to read the inscrutable riddle of Nature.

I venture to assert that nowhere is this struggle more succinctly and definitively illustrated than in the story of man's effort to formulate the hypotheses which constitute the foun-

Printed May 13.

dations of geometry. For precise reasons, the names of Euclid and Newton stand above all other names in the *fasti* of mathematics; and the reasons are strikingly similar in the two cases. In writing of *The Wonderful Century*, the nineteenth, Alfred Russel Wallace says of all time before the seventeenth century: "Then, going backward, we can find nothing of the first rank except Euclid's wonderful system of geometry, perhaps the most remarkable mental product of the earliest civilizations." In modern times, Newton's colossal figure occupies the centre of the stage, looming large, as he himself explained, because he stood upon the shoulders of giants. Like Euclid, his claim to pre-eminence rests less upon the discovery of new principles than upon the immeasurably greater service of the universal formulation and grounding of mathematics. Newton brought all natural phenomena under the reign of universal law, Euclid reduced all geometrical knowledge to system.

"It is certain," says Philip Kelland, "that from its completeness, uniformity and faultlessness, from its arrangement and progressive character, and from the universal adoption of the completest and best line of argument, Euclid's *Elements* stand pre-eminently at the head of all human productions. In no science, in no department of knowledge, has anything appeared like this work: for upwards of 2,000 years it has commanded the admiration of mankind, and that period has suggested little toward its improvement." Indeed it is no cranky enthusiasm, but absolute conviction that prompts the mathematician to say that geometry is ultimately fundamental for the progress of science and thea dvancement of humanity. It is continually bringing to pass those epoch-making events in the history of science whereby what one day seems to be the purest science becomes the next a vitally important piece of applied science. Such events enable us to realize that pure science and utilitarian science are not differentiable, buta t bottom and in essence one and the same thing. "I often find the conviction forced upon me," said the brilliant English

geometer H. J. S. Smith, "that the increase of mathematical knowledge is a necessary condition for the advancement of science, and, if so, a no less necessary condition for the improvement of mankind. I could not augur well for the enduring intellectual strength of any nation of men, whose education was not based on a solid foundation of mathematical learning, and whose scientific conceptions, or, in other words, whose notions of the world and of the things in it, were not bound and girt together with a strong framework of mathematical reasoning."

In that charming book, cast in the dialogue form and entitled *Euclid and his Modern Rivals*, by the Rev. Charles L. Dodgson, the brilliant "Lewis Carroll" of *Alice in Wonderland* fame, Euclid confesses with reluctance that some secret flaw lies at the root of the subject of parallel lines. Probabilities, not certainties, are all that he has in vindication of his belief. Here we lay our fingers on the rift in the lute; in this confession, we catch a glimpse of that *ignis fatuus* that mathematicians have pursued in vain for well-nigh two thousand years. Professor G. B. Halsted cites Sohncke* as saying that in mathematics there is nothing over which so much has been spoken, written, and striven, as over the theory of parallels, and all, so far (up to his time), without reaching a definite result and decision. It is impossible, says the great Poincaré, to imagine the vast effort wasted in this chimeric hope, this evanescent dream. Indeed, it was not until the nineteenth century that the truth began to dawn upon the minds of men; and almost simultaneously from the distant frontiers of Europe, at Kazan on the Volga and at Maros-Vasarhely in far Erdély, there came the startling generalizations that have tended to revolutionize our conceptions of geometry, and thrown doubts upon the very nature of the space in which we live.†

Encyclopædie der Wissenschaften und Kunste; Von Ersch und Gruber, Leipzig, 1838, under "Parallel."

†Compare *The Value of Non-Euclidian Geometry*, by G. B. Halsted; Pop. Sci. Monthly, vol. 67, pp. 639-646. At the outset, I wish to acknow-

In order to make the matter clear to "the man in the street," it is necessary to speak, not so much as a mathematician as one who knows, let us say, no more of mathematics than is taught in the Freshman year in the college or university. We recall that Euclid uses three terms in laying the foundations for his geometry: *Definitions* ('όμοι), *Postulates* (αιτιήματα), and *Common Notions* (κοιναι εννοιαι). He defined his elements: point, line, etc.; he assumed that you can draw a straight line from one point to another; and he laid down as accepted such statements as "Things equal to the same thing are equal to each other," etc. For Euclid's *Common Notions* later geometers substituted the unfortunate term—unfortunate, as we shall subsequently see—*Axioms*. This word Axiom (Greek, αξιωμα) is used by Aristotle to mean "a truth so obvious as to be in no need of proof"—virtually in the modern sense of a "self-evident truth." Euclid used only five Postulates and thirteen Common Notions, none of which challenged doubt save the celebrated "parallel-postulate." Indeed, all were very simple except this fifth postulate,* which excited suspicion, not only on account of its cumbrous form, but because it is used only once—to prove the inverse of a proposition already demonstrated—the seventeenth. "It requires," says Staeckel, "a certain amount of courage to declare such a requirement, alongside the other simple axioms and postulates." The Swiss mathematician, J. H. Lambert,† averred that Proklos, Euclid's first commentator (410–485 A. D.) argued that the parallel-postulate was demonstrable, because it was the inverse of the seventeenth proposition. Euclid's twenty-seventh proposition: that straight lines

ledge my general indebtedness to the writings of Professor Halsted, to which I occasionally refer.

*Also given in various editions of Euclid as a Common Notion—eleventh, twelfth, or thirteenth.

†Lambert's *Theory of the Parallel Lines* was not published until 1786 twenty years after it was written and nine years after his death, by Bernouilli and Hindenberg in the *Magazin fur die reine und angewandte Mathematik.*

making with a transversal equal alternate angles are parallel, is easily demonstrated. But in order to prove its inverse: that parallels cut by a transversal make equal alternate angles, he is forced to resort to the following postulate axiomatically stated (Williamson's translation, Oxford, 1781):

11. *And if a straight line meeting two straight lines makes those angles which are inward and upon the same side of it less than two right angles, the two straight lines being produced indefinitely will meet each other on that side upon which the angles are less than two right angles (Fig. 1, Angle A + Angle B less than 180°).*

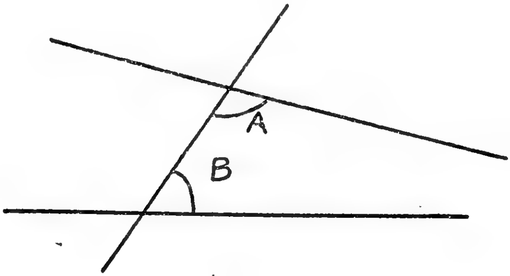


FIG 1.

The points to be observed in connection with this postulate are two in number. First, "no one had a doubt of the external reality and exact applicability of the postulate. The Euclidian geometry was supposed to be the only possible form of space-science, that is, the space analyzed in Euclid's axioms and postulates was supposed to be the only non-contradictory sort of space." Second, the postulate was neither so axiomatic nor so simple as the proposition it was used to prove; and hence the world of mathematicians concluded, with Proklos, that this postulate could be deduced as a theorem from the other assumptions and the twenty-eight preceding theorems. And so, for hundreds and hundreds of years, the

mathematical world exhausted itself in the effort to prove Euclid's celebrated parallel-postulate. Ptolemy, the great astronomer, wrote a treatise purporting to prove it; and Nasir Eddin (1201-1274), whose work on Euclid in Arabic was printed at Rome in 1594, sought to dispense with the problem of parallelism, by taking his stand upon another postulate: that two straight lines which cut a third straight line, the one at right angles, the other at some other angle, will converge on the side where the angle is acute, and diverge where it is obtuse. Other mathematicians, notably John Wallis whom I claim as an ancestor, sought to turn the flank of the difficulty by identifying the problem of parallels with the problem of similitude. In general, we may say that the problem was attacked from three sides.

First, there were those who sought to substitute a new definition of parallels for Euclid's, which reads (I, Def. 35):

> "*Parallel straight lines are such as are in the same plane, and which being produced ever so far both ways do not meet.*"

To cite a few classic definitions, Wolf, Boscovich, and T. Simpson use the following: "Straight lines are parallel which preserve the same distance from each other." But this is begging the question, asHalsted has remarked, since it assumes a *definition*, viz.: "Two straight lines are parallel when there are two points of the one on the same side of the other from which the perpendiculars to it are equal;" and at the same time assumes a *theorem:* "All perpendiculars from one of these lines to the other are equal." Those geometers who assume that parallel lines have the same direction are guilty of a *petitio principii*, in assuming (Varignon and Bezout) the *definition* that "parallel lines are those that make equal angles with a third line," and also in assuming the *theorem* that "Straight lines that make equal angles with one transversal make equal angles with all transversals."

The second method of attack, far more logical, was to pro-

pose a substitute for the parallel-postulate, such as "Two straight lines which intersect cannot *both* be parallel to the same straight line" (Ludlam), and "Any three points are collinear or concyclic" (Bolyai). And the celebrated Hilbert, in his *Vorlesung ueber Euklidische Geometric*, (winter semester, 1898-9) cites the following theorems:

1. The sum of the angles of a triangle is always equal to two right angles.
2. If two parallels are cut by a third straight line, then the opposite (corresponding) angles are equal.
3. Two straight lines, which are parallel to a third, are parallel to each other.
4. Through every point within an angle less than a straight angle, one can always draw straight lines which cut both sides (not perhaps their prolongations).
5. All points of a straight line have from a parallel the same distance.

His comment is, "Finally we remark, that it seems as if each of these five theorems could serve precisely as the *equivalent of the Parallel Axiom.*"

The third class of investigators consisted of those geometers who foundered upon the rock of the attempt to deduce Euclid's parallel-postulate from reasonings about the nature of the straight line and the plane angle, helped out by Enclid's other assumptions and his first twenty-eight theorems. Euclid took pains to prove things which were more axiomatic by far—for instance, that the sum of two sides of a triangle is greater than the third side—a thing which any ass knows. To give one illustration of the many so-called proofs, take the most plausible one, exposed by Charles L. Dodgson, in his *Curiosa Mathematica*, Part I. pp. 70-71, 3rd edition, 1890:

"Yet another process has been invented—quite fascinating in its brevity and its elegance—which, though involving the

same fallacy as the Direction-Theory, proves Euc. I, 32, without even mentioning the dangerous word 'Direction'.

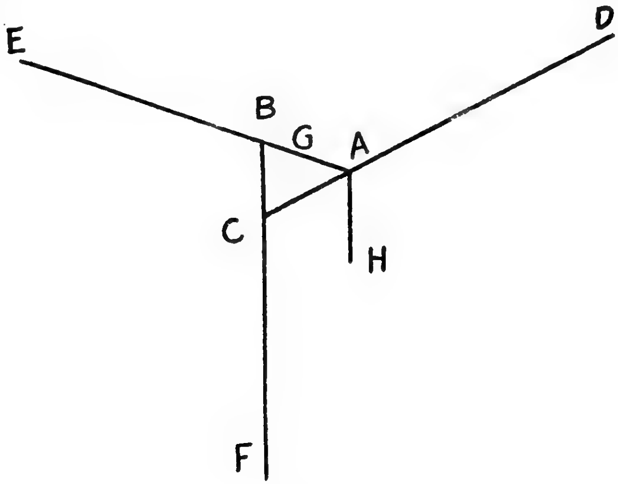


FIG. 2.

"We are told to take any triangle ABC; to produce CA to D; to make part of CD, viz., AD, revolve, about A, into the position ABE; then to make part of this line, viz., BE, revolve, about B, into the position BCF; and lastly to make part of this line, viz., CF, revolve, about C, till it lies along CD, of which it originally formed a part. We are then assured that it must have revolved through four right angles: from which it easily follows that the interior angles of the triangle are together equal to two right angles.

"The disproof of this fallacy is almost as brief and elegant as the fallacy itself. We first quote the general principle that we can not reasonably be told to make a line fulfil *two* conditions, either of which is enough by itself to fix its position: e. g., given three points X, Y, Z, we can not reasonably be told to draw a line from X which shall pass through Y *and* Z; we can make it pass through Y, but it must then take its chance of passing through Z; and *vice versa*.

"Now let us suppose that, while one part of AE, viz., BE, revolves into the position BF, another little bit of it, viz., AG, revolves, through an equal angle, into the position AH; and that, while CF revolves into the position of lying along CD, AH revolves—and here comes the fallacy.

"You must not say 'revolves through an equal angle, into the position of lying along AD,' for this would be to make AH *fulfil two conditions at once.*

"If you say that the one condition involves the other, you are virtually asserting that the lines CF, AH are equally inclined to CD—and this in *consequence* of AH having been so drawn that these same lines are equally inclined to AE.

"That is, you are asserting, 'A pair of lines which are equally inclined to a certain transversal, are so to any transversal.' [Deducible from Euc. I, 27, 28, 29]."

Thousands of mathematicians have tried in vain to prove something that only a genius could see was indemonstrable. The history of the evolution and exfoliation of that fertile idea is of very great interest to the mathematician of today, especially in view of the fact that beyond contradiction the most original researches of the last quarter of the nineteenth century pertain to the non-Euclidian geometry.

The most notable attempt to demonstrate Euclid's parallel-postulate that has been preserved to the world is embodied in a book entitled *Euclid Vindicated from every Blemish*, by a Jesuit priest named Hieronymus Saccheri (1667-1773).* He was in close association with the great Italian geometer Giovanni Ceva (through his brother Tommaso), whose name a celebrated theorem bears; and by purely geometrical methods in Euclidian style, he sought to apply the *reductio ad absurdum* method to the problem of the parallel-postulate. His method is essentially as follows: At the end-points of a sect AB erect two equal perpendiculars AC and BD on the

**Euclides ab omni naevo vindicatus; sive conatus geometricus quo stabiliuntur prima ipsa universae geometriae principia.* Auctore Hieronymo Saccherio Societatis Jesu, Mediolani.

same side of AB. Join C and D by a straight line; and it easily follows that the angle ACD is equal to the angle BDC. Now there are three possibilities: (1) The angle ACD is acute; (2) the angle ACD is obtuse; (3) the angle ACD is a right angle. He undertook to prove the absurdity of the first two possibilities so as to leave only the third possibility, viz., that the two angles ACD and BDC are each right angles. He pursued the lines of argument, following from the first two assumptions, at some length—for his book was more than a hundred pages long; but was doubtless amazed to discover that for quite a time he was unable to involve himself in any logical contradiction. In the event, certain of his conclusions were erroneous, and led him to believe that he had actually proved the parallel-postulate. What he really did do was to identify the assumption of the right angle with the parallel-postulate, thus showing the two to be mutually interchangeable postulates.

In 1766, Johann Heinrich Lambert wrote his theory of parallel lines, in which he starts from the notion of the sum of the angles of a triangle being equal to 180 degrees. If the sum is equal to 180 degrees, the triangle is a figure in a plane; if the sum is greater than 180 degrees, the triangle is on a sphere; if the sum is less than 180 degrees, the triangle is on the surface of an imaginary sphere (radius equal to the square root of minus one)--Lobatchevsky--Bolyai "imaginary geometry," so called because its trigonometric formulas are those of the spherical triangle if its sides are imaginary. As to the third hypothesis, Lambert naïvely said: "There is something attractive about this which easily suggests the wish that the third hypothesis might be true."*

France contributed little to the solution of the problem; recognition, however, should be given to Legendre, who stud-

*Compare *The Philosophical Foundations of Mathematics*, by Dr. Paul Carus; The Monist, vol. 13, pp. 273-294; 370-397; 493-522, to which I am indebted. I once had the pleasure of hearing Dr. Carus lecture on this snbject before the Mathematical Club of the University of Chicago.

ied the problem all his life. By the aid of the principle of continuity, the so-called Theorem of Archimedes, he did prove two well known theorems:

1. In a triangle, the sum of the three angles can never be greater than two right angles.
2. If the sum of the three angles is equal to two right angles in one triangle, it is equal to two right angles in every triangle.

But Euclid's geometry can be built up without the continuity assumption; and only a short time ago, there was proved by Dehn, something that might have been inferred, viz., that Legendre's first theorem does not hold, i. e. not without the continuity assumption.*

In addition to Legendre, there was one other Frenchman, Joseph Lagrange, France's greatest mathematician in his day, who attempted to prove Euclid's parallel-postulate. Toward the end of his life, so the story runs, Lagrange composed a discourse on parallel lines. He began to read it in the Academy, but suddenly stopped, and, in confusion, stammered: "Il faut que j'y songe encore"—"I'll have to think about it a while longer." He stuck his manuscript in his pocket, sat down, and never recurred to the subject.

The first distinct epoch in the history of the non-Euclidian geometry begins with the time of the great German mathematician, Karl Friedrich Gauss. He is in no sense entitled to credit as a discoverer in this line, although for many years he occupied himself with the problem. The researches he claims to have made on the subject have not come down to us; but he was closely associated, according to abundant testimony, with Schweikart and Bolyai, two of the three independent discoverers of the non-Euclidian geometry. The publication in 1900 of the eighth volume of Gauss' *Collected Works* shows, from a letter to Bolyai, the elder, a Hungarian mathe-

*Compare *The Foundations of Geometry*, by David Hilbert; Translation by E. J. Townsend, Open Court Publishing Co., Chicago.

matician, that in 1779 Gauss was still hopelessly attempting to prove that Euclid's was the only non-self-contradictory system of geometry, and also the system of our space. Bolyai, the elder, submitted to Gauss, in 1804, a pseudo-proof of the parallel-postulate, but Gauss immediately detected the fallacy. When Bolyai, the elder, submitted a second pseudo-proof to Gauss, in 1808, he never replied. Bolyai's words, accompanying one of these pseudo-proofs, are pathetic in their earnestness and yearning: "Oft have I thought, gladly would I, as Jacob for Rachel, serve in order to know the parallels founded even if by another. Now just as I thought it out on Christmas night, while the Christians were celebrating the birth of the Saviour in the neighboring church, I wrote it down yesterday, and I send it to you enclosed herewith."

On November 23, 1823, Bolyai the son, called Janos, wrote a letter to his father, professor of mathematics at Maros-Vasarhely, in which he announces his discovery of the non-Euclidian geometry—a letter full of youthful fire and enthusiasm, from which I quote:

> "I intend to write, as soon as I have put it into order, and when possible to publish, a work on parallels. At this moment it is not yet finished, but the way which I have hit upon promises me with certainty the attainment of the goal, if it in general is attainable. It is not yet attained, butI have discovered such magnificent things that I myself am astounded at them.
>
> "It would be damage eternal if they were lost. When you see them, father, you yourself will acknowledge it. Now I cannot say more of them, only so much: *that from nothing I have created another wholly new world.* All that I have hitherto sent you compares to this only as a house of cards to a castle."*

His results were printed as an *Appendix* to his father's work, entitled *Tentamen Juventutem Studiosam in Elementa Matheseos Purae, Elementaris ac Sublimioris, Methodo Intuitiva, Evidentia—que huic Propria Introducendi.* The two dozen pages contributed by the younger Bolyai have been some-

***The Science Absolute of Space*, by John Bolyai, translated by G. B. Halsted; Introduction, pp. XXVII, XXVIII.

what exaggeratedly characterized as the most remarkable two dozen pages in the history of thought. When this work at last reached Gauss, he wrote to his pupil and friend, Gerling: "I hold this young geometer von Bolyai to be a genius of the first magnitude." Bolyai called his work, *The Science Absolute of Space, independent of the truth or falsity of Euclid's Axiom XI (which can never be decided* A PRIORI). And later, we read on the title page of the elder Bolyai's *Kurzer Grundriss*: "the question, *whether two straight lines, cut by a third, if the sum of the interior angles does not equal two right angles, intersect or not?* no one on the earth can answer without assuming an axiom (as Euclid the eleventh)." The work of Bolyai, the younger, which makes all preceding space only a special case, only a species under a genus, and requiring a descriptive adjective *Euclidian*, was rescued from oblivion, after thirty years, by Professor Richard Baltzer, of Dresden; and J. Hoüel, of Bordeaux, following in the steps of Baltzer, inserted extracts from Bolyai's book in his *Essai Critique sur les principes fondamentaux de la Geometrie elementaire.* Indeed, this scientist mastered the principal European languages in order to make known to his contemporaries the most celebrated mathematical works.

There is another name which deserves to become conspicuous in the history of non-Euclidian geometry; but not until 1900 were the facts in connection with his independent discovery accurately known. In a letter to the elder Bolyai, written October 31, 1851, Gerling, a scholar of Gauss and Professor of Astronomy at Marburg, wrote as follows: "We had here about this time (1819) a law professor Schweikart, who ...... had attained to similar ideas, since without help of the Euclidian axiom he developed in its beginnings a geometry which he called Astralgeometry. What he communicated to me thereon I sent to Gauss, who then informed me how much farther already had been attained on this way, and later also expressed himself about the acquisition, which is offered to the few expert judges in the Appendix to your

book." On the publication of volume 8 of Gauss's *Collected Works*, in 1900, light is at last thrown upon Schweikart's discovery. Here we find Gerling's actual letter to Gauss, written in 1819, in which he says, among other things: "Apropos of the parallel-theory, ... I learned last year that my colleague Schweikart .... had written on parallels........ He said that he was now about convinced that without some datum the Euclidian postulate could not be proved, also that it was not improbable to him that our geometry is only a chapter of a more general geometry."* Enclosed in this letter was a paper by Schweikart, dated Marburg, December, 1818. From this we learn:

> "There is a two-fold geometry—a geometry in the narrower sense—the Euclidian, and an astral science of magnitude.
>
> "The triangles of the latter have the peculiarity, that the sum of the three angles (of a triangle) is not equal to two right angles.
>
> '*This* presumed, it can be most rigorously proven:
>
> (a) That the sum of the three angles in the triangle is *less* than two right angles;
>
> (b) That this sum becomes ever smaller, the more content the angle encloses;
>
> (c) That the altitude of an isoscles right angled triangle indeed ever increases, the more one lengthens the side; that it, however, cannot surpass a certain line, which I call the *constant*."

It can be easily proved that if this constant is infinitely great, then, and then only, is the sum of the three angles of every triangle equal to two right angles.

That the doctrine made converts in high places is evidenced by Bessel's letter to Gauss, Feb. 10, 1829: "Through that which Lambert said, and what Schweikart disclosed orally, it

***Gauss and the non-Euclidian Geometry*, by G. B. Halsted; Science, N. S. Vol. XII, No. 309, pp. 842–846, Nov. 30, 1900.

has become clear to me that our geometry is incomplete, and should receive a correction, which is hypothetical, and if the sum of the three angles is equal to one hundred and eighty degrees, vanishes.

"That were the *true* geometry, the Euclidian, the *practical*, at least for figures on the earth."*

The third name most closely associated in the popular mind with the discovery of the non-Euclidian Geometry is that of Nicolai Ivanovich Lobatchevsky. This brilliant genius, afterwards dubbed by Hoüel the modern Euclid, was born in the year 1793 near Nijni Novgorod on the Volga. He studied under the great Bartels, was graduated with distinction, became professor of mathematics, and finally rector, of the University of Kazan. The manuscripts of certain of his works were lost, but fortunately there remains the world-famous *Geometrical Researches on the Theory of Parallels.*† While both Gauss and Lobatchevsky were students of Bartels, there is even less reason to believe that Gauss contributed to Lobatchevsky's, than that he assisted in Bolyai's, discovery of the non-Euclidian geometry. In his *New Elements of Geometry*, we find Lobatchevsky's clear enunciation:

> "The futility of the efforts which have been made since Euclid's time during the lapse of two thousand years awoke in me the suspicion that the ideas employed might not contain the truth sought to be demonstrated. When finally I had convinced myself of the correctness of my supposition I wrote a paper on it (assuming the infinity of the straight line).
>
> "It is easy to show that the straight lines making equal angles with a third never meet.
>
> "Euclid assumed inversely, that two straight lines unequally inclined to a third always meet.
>
> "To demonstrate this latter assumption, recourse has been had to many different procedures.

**The Philosophical Foundations of Mathematics*, by Paul Carus; The Monist, vol. 13. p. 280.

†Compare the English translation by G. B. Halsted, published by the University of Texas, Austin, 1891.

"All these demonstrations, some ingenious, are without exception false, defective in their foundations and without the necessary rigor of deduction."

Lobatchevsky classifies all the co-planar lines through a given point A with reference to another co-planar line BC not passing through A, under two heads—cutting and non-cutting (Fig. 3). The transition from the non-cutting lines,

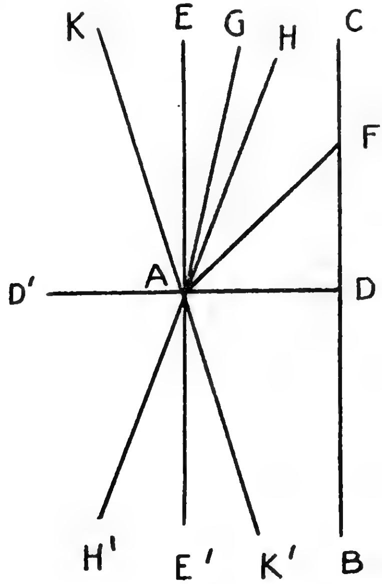


FIG 3.

such as EA and GA, to the cutting lines, such as FA, is marked by one line HA—the boundary line between the two classes; this he entitles the *parallel line*. From the assumptions, there arises the necessity of making a distinction of *sides in parallelism*, and hence there must be two parallels, so-called, one on each side. One logical consequence of this is that "if in any rectilineal triangle the sum of the three angles is equal to two right angles, this is also the case for every triangle"—one instance is the criterion for all.

As Poincaré, perhaps the world's greatest living mathematician, recently said, in his review of Hilbert's *Grundlagen der Geometrie*:

> "Lobachevski succeeded in building a logical edifice as coherent as the geometry of Euclid, but in which the famous postulate is assumed false, and in which the sum of the angles of a triangle is always less than two right angles. Riemann devised another logical system, equally free from contradiction, in which the sum is, on the other hand, always greater than two right angles. These two geometries, that of Lobachevski and that of Riemann, are what are called the *non-Euclidian Geometries.* The postulate of Euclid then cannot be demonstrated; and this impossibility is as absolutely certain as any mathematical truth whatsoever."*

Limits of space forbid more extended treatment of the work of Schweikart, of Bolyai, and of Lobatchevsky. By no means secondary in interest to the investigations of these men are the researches of Riemann upon the Elliptic Geometry; Cayley's projective theory of measurement, and the Absolute, leading through Klein to the non-Euclidian geometry; the hypotheses advanced by Clifford to explain the nature of the space in which we live; the popular expositions of Helmholtz; and Lie's great group-theoretic structure built upon the hypothesis of *Zahlenmannifaltigkeit.* Nor can I enter, at this place, into any discussion of the recent movement toward the treatment of geometry as a whole from the purely synthetic standpoint, inaugurated by Pasch, carried on by Peano, Pieri, and Veronese, and crowned by the masterly work of Hilbert. These modern investigators in what has been fittingly termed *abstract mathematics* have exhibited the potency of symbolism in removing from attention the

*Compare *The Value of Non-Euclidian Geometry*, by G. B. Halsted; Pop. Sci. Monthly, vol. 67, pp. 642-3.

concrete connotations of the ordinary terms of general and mathematical language. And yet, as Professor E. H. Moore has pertinently suggested, "the question arises whether the abstract mathematicians in making precise the metes and bounds of logic and the special deductive sciences are not losing sight of the evolutionary character of all life-processes, whether in the individual or in the race. Certainly the logicians do not consider their science as something now fixed. All science, logic and mathematics included, is a function of the epoch—all science, in its ideals as well as in its achievements.......... One has then the feeling that the carrying out in an absolute sense of the program of the abstract mathematicians will be found impossible. At the same time, one recognizes the importance attaching to the effort to do precisely this thing. The requirement of rigor tends toward essential simplicity of procedure, as Hilbert has insisted in his Paris address, and the remark applies to this question of mathematical logic and its abstract expression."*

Perhaps a not unnatural confusion may arise in the mind of the layman in regard to the ultimate meaning, the far-reaching significance of these discoveries. As Artemus Ward used to say, "Why this thusness?" Indeed so revolutionary have many of the new theories and discoveries appeared that their authors, in more than one instance, have hesitated long before giving them to the world. The pioneers in science sometimes dread, not inadvisedly, the possibility that their startling and epoch-making hypotheses and investigations may lead them to be dubbed sensationalists and fakirs. Compare, for example, the letter Gauss wrote to Bessel, Jan. 27, 1829:

> "I have also in my leisure hours frequently reflected upon another problem, now of nearly forty years standing. I refer to the foundations of geometry. I do not know whether I have ever mentioned to you my views on this matter. My meditations have also taken

**On the Foundations of Mathematics*, by E. H. Moore. Presidential address, Am. Math. Soc., Dec. 29, 1902. *Science*, March 13, 1903, pp.401-416.

> more definite shape, and my conviction that we cannot thoroughly demonstrate geometry *a priori* is, if possible, more strongly confirmed than ever. But it will take a long time for me to bring myself to the point of working out and making public my *very extensive* investigations on this subject, and possibly this will not be done during my life, inasmuch as I stand in dread of the clamor of the Bœotians, which would be certain to arise if I should ever give *free* expression to my views."

As that wayward Irishman, Bernard Shaw, has said, the prime and indispensible quality of the pioneer must be his willingness to make a fool of himself—at first! And it matters not in what sphere, whether art, literature or science, the great thing, as Henrik Ibsen says, is not to allow one's self to be frightened by the venerableness of the institution.

Now that the truth in regard to many of the mooted questions which pertain to the foundations of geometry has at last been daringly disclosed, the first question that naturally arises is : Has Euclid's fame suffered by the discovery ? One might be led to think so if dependence were to be placed in Clifford's characterization of Lobatchevsky's celebrated monograph as "Euclid without the vicious assumption." Such a remark is not only misleading: it displays a fundamental misapprehension in regard to the Euclidian and non-Euclidian geometries. The real truth of the matter is that Euclid's genius today shines forth more resplendently than ever ; the almost flawless perfection of his work is only thrown into clearer perspective and higher relief. From the purely philosophical, the metaphysical point of view, the discovery of the non-Euclidian geometry is of vast interest ; for it gives rise to endless speculations in regard to the character of space—even of inter-stellar space. Are the three angles of a triangle equal to two right angles if the sides of the triangle are the distances from the earth to the remotest fixed star ? In the realization that Euclidian geometry is only a chapter in a more general geometry, fitly entitled Pan-Geometry, and the consequent almost infinite extension of the domain of research consists the great value of the discovery to the mathemati-

cian. Most interesting comparisons between the different types of geometry flow from a study of certain surfaces. Since the sum of the three angles of a spherical triangle is greater than two right angles, it is evident that the characteristic geometry of the sphere is Riemannean ; it has been known, since Lobatchevsky and Bolyai, that the characteristic geometry of the orisphere is Euclidian; since Beltrami, that of the Euclidian pseudo-sphere is Lobatchevskian.* Such generalizations as Barbarin's Theorem, for example, link together the various types of geometry in a most succinct and illuminative fashion, exhibiting with great clarity their fundamental distinctions and similarities. Text books in non-Euclidian geometry are now being written ; Professor Halsted entitles a popular article *The Non-Euclidian Geometry Inevitable.* The first step toward the popularization of non-Euclidian geometry is the clear enunciation, at the proper place in our ordinary text-books of geometry, of the principle on which the Euclidian geometry rests : that from the standpoint of pure logic the parallel-postulate is a mere choice between alternatives. "In all the books put into the hands of students," as M. Barbarin has said, "the hypothetical and wholly factitious character of the Euclidian postulate (should) be put well into relief."†

The second great gain from the discovery of the non-Euclidian geometry is the possibility of the formulation of the principles of the general geometry. It is most instructive and stimulating to the mathematical student to see the theories of Euclidian geometry emerge as special cases of the more general and comprehensive theories of Pan-Geometry. The

*If we consider the tubes or surfaces equidistant from a straight line, and make that distance infinite, we have the orispheres; the pseudo-spheres are surfaces of revolution which have for meridians a tractrix or line of equal tangents. A pseudo-sphere finds its approximate counterpart in nature in a morning-glory whose stem is infinitely prolonged; for a figure, cf. *Elements of Trigonometry*, by Phillips and Strong, p. 126.

†*On the Utility of Studying Non-Euclidian Geometry*, by P. Barbarin; Le Mathematiche, May, 1901.

general geometry contains many propositions common to all the systems, which should be enumerated in the same terms in each of these. Sometimes a modification in the form of statement, veiling the special property of the figure in the particular type of space, would result from a generalization of the theorems for the general geometry, in which case such special properties should be clearly indicated. Thus, to state an illustration cited by M. Barbarin,* that of the convex quadrilateral inscribed in a circle, in Euclidian geometry, *the sum of two opposite angles is constant and equal to two right angles*; in non-Euclidian geometry, *this sum is variable.* Notwithstanding this, the two forms may be reconciled, since in both cases *the sum of two opposite angles equals that of the other two*, and this is sufficient for a convex quadrilateral to be inscriptible. Such generalizations often lead to a complete redistribution of values, and so clarify the processes of Euclidian geometry in the most distinctive way. Professor E. Study has said:

> "The conception of geometry as an experimental science is only one among many possible, and the standpoint of the empiric is as regards geometry by no means the richest in outlook. For he will not, in his one-sidedness, justly appreciate the fact that in manifold, and often surprising ways the mathematical sciences are intertwined with one another, that in truth they form an indivisible whole.
>
> "Although it is possible and indeed highly desirable that each separate part or theory be developed independently from the others and with the instrumentalities peculiar to it, yet whoever should disregard the manifold interdependence of the different parts, would deprive himself of one of the most powerful instruments of research.
>
> "This truth, really self-evident yet often not taken to heart, applied to Euclidian and non-Euclidian geometry, leads to the somewhat paradoxical result that, among conditions to a more profound understanding of even elementary parts of the Euclidian geometry, the knowledge of the non-Euclidian geometry cannot be dispensed with."†

**On the Utility of Studying non-Euclidian Geometry*, l. c.

†*Ueber Nicht-Euklidische und Linien-Geometrie*, Greifswald, 1900.

Lastly, the discovery of the non-Euclidian geometry virtually fixes upon the Euclidian geometry its practical and empirical character. "In connecting a geometry with experience," to cite the view of the most confirmed of non-Euclidians, "there is involved a process which we find in the theoretical handling of any empirical data, and which therefore should be familiarly intelligible to any scientist. The results of any observations hold good, are valid, always only within definite limits of exactitude and under particular conditions. When we set up the axioms, we put in place of these results statements of absolute precision and generality. In this idealization of the empirical data our addition is at first only restricted in its arbitrariness in so much as it must seem to approximate, must apparently fit, the supposed facts of experience, and, on the other hand, must introduce no logical contradiction. Thus to-day the ordinary triply-extended space of our experience may be purely Bolyaian, or purely Euclidian, or purely Cliffordian, or purely Riemannian."* To put it extravagantly, the non-Euclidian geometer, like a croupier, cries out to his audience: "Here are three assumptions in regard to the angle sum of a triangle; from not one of the three do any logical contradictions follow; which one will you take? *Messieurs, faites vos jeux!*" The result is, not that the mathematical world singles out one to the exclusion of the others—but studies all three, their inter-actions, inter-relations, and mutual dependencies. And yet if the "man in the street" impatiently cries out: "I am not interested in what may be the possible nature of space in the vicinity of Mars, or even the possible character of geometrical figures on the planet Jupiter, or in the tortuous reasonings of a mathematical Alice in Wonderland. Tell me, what is the character of the space I occupy, the nature of the physical world in which I live and move and have my being?" And the answer of mathematicians throughout the world, with certain distinguished exceptions,

**The Appreciation of non-Euclidian Geometry*, by G. B. Halsted; *Science*, March 22, 1901, pp. 462-465.

would doubtless be: "Although it can never be mathematically demonstrated, our space I believe to be Euclidian space because of the testimony of experience." The three angles of a triangle can never be mathematically demonstrated to be equal to two right angles; nor can experience ever give the absolutely exact metric results desiderated. And yet, this thing amounts to what we crudely call "moral certainty", viz. that the "practical geometry", as Bessel rightly called it, within reasonable limits of error—for which we must always allow in this imperfect world—, and for limited portions of space, is Euclidian. So, after all, it seems that we are forced to the conclusion that the axioms of geometry, although they are, abstractly speaking, assumptions, are, practically speaking, deductions from experience. Only as suppliants at the feet of Nature herself can we ever hope to penetrate to the heart of her mystery.

A NEW COLOR TEST FOR THE LIGNOCELLULOSES.

ALVIN S. WHEELER.

The lignocelluloses give a number of color reactions, the most valuable being the reaction with phloroglucinol in hydrochloric acid solution. The rich reddish violet color is very pronounced. The salts of anilin give a golden yellow but the color is not sufficiently dark to allow them to compete with phloroglucinol. However, I have observed that the salts of the nitranilines produce a color which is very striking, a rich blood red color. As phloroglucinol solutions are said to deteriorate with age, I have kept for one year exposed to full daylight a hydrochloric acid solution of phloroglucinol and also one of paranitraniline. The phenol solution became brown, showing some decomposition and on applying it to pine sawdust the violet color was not fully developed instantly but in a few minutes became as dark as that made by a fresh solution. The nitraniline solution was perfectly stable and gave its reaction as quickly as a fresh solution. So far as a year's time is concerned the new reagent has no real advantage over the old.

The red color is produced by the salts of the ortho, meta and paranitranilines but the meta compounds are much inferior, the color being pale in comparison. The ortho and para compounds give the same deep color. Paranitraniline is to be preferred since it is more readily obtained. Different salts of this amine such as sulphate, nitrate, hydrobromide and hydrochloride were tested but no difference was noted. The hydrochloride was adopted for use. This salt, dissolved in pure water, only gives a yellow color, but on stand-

ing for some hours the red color develops. Since the best results are obtained when free acid is present, various strengths of hydrochloric acid were tried from one-half to a twelve per cent. solution but no important difference could be observed. It is convenient to use an acid of specific gravity 1.06. A study of various concentrations of the paranitraniline in acid solution revealed no differences of consequence. It was observed that in all cases hot solutions produced much quicker results than cold ones. In fact hot solutions seemed to give the full depth of color instantaneously.

The reagent was applied to a wide variety of woods, to jute, to oat straw and to many samples of paper. A No. 1 book paper showed numerous small red fibres, indicating adulteration with mechanical wood or else incomplete conversion of the lignocellulose. A yellow paper containing five per cent. of mechanical wood gave a deeper color, likewise a salmon pink paper. A very deep blue paper made of sulphite cellulose showed scattering red fibres which were easily seen. A sample of white paper made from bleached sulphite gave no trace of color.

A striking lecture experiment is carried out by projecting a quantity of the hot solution against a large sheet of paper made of mechanical wood, such as newspaper stock.

In conclusion, the reagent is made by dissolving two grams of paranitraniline in one hundred cubic centimeters of hydrochloric acid, either of specific gravity 1.06 or a 4N solution. When used hot, a blood red color is instantaneously obtained with lignocelluloses.

University of North Carolina,
February 21, 1907.

NOTES ON THE GEOLOGY OF CORE BANK, N. C.

BY COLLIER COBB.

The storm of October 17th, 1906, cut three inlets across Core Bank, just below Cedar Island Inlet (closed since 1805) and near the site of Old Drum Inlet (closed in 1822), and revealed the fact that the beach sands and dunes (Columbia) rest upon a clay foundation (Neocene), which in its turn is underlaid by Tertiary shell-rock, exactly similar to the shell rock occurring at various points in Currituck Sound and already noted in this Journal.* Among the forms observed here were *Turritella*, *Lunatia*, *Glycymeris*, *Tornatellaea*, *Nucula*, *Lucina*, *Corbula*, *Protocardia*, *Modiolus*, *Arca*, *Ostrea*. These were in most cases packed together in the shell-rock, and a few sharks' teeth were included. The upper portion of this rock was made up almost entirely of the shells of *Tellina*. After the storm the entire bank in the region of the new-formed inlets was black with magnetic sands, heavily ripped, their thicknes being in some cases as much as three inches.

Numerous water-worn shells of *Cardium*, *Anomia*, *Exogyra*, *Serpula*, *Gryphaca*, of species identical with those found by the writer on Currituck Banks, were washed up by the storm, as were also the bones of fishes, all these being Cretaceous fossils. Many coral fragments were also found. The Captain of the Core Bank Life Saving Station, Willis, sailed through one of the inlets and found six feet of water in its shallowest part. On December 16th, 1906, I walked across all three of the inlets at low water in company with Captain Wm. T. Willis of the Core Bank Life Saving Station,

*Vol. xxii, No. 1, 1906, pp 17-19.

and Mr. R. C. Holton of Atlantic, the washing up of sand from the sea and the southward movement of the dunes having nearly filled them.

The Tertiary shell-rock was encountered in Core Sound between Core Bank and Cedar Island, and between Core Bank and the mainland. There is thus no longer any question as to the origin of Core Bank or of Currituck Bank, for they are both essentially parts of the mainland. Currituck Sound was formerly a river that flowed into the Albemarle or Caroline River before the present Albemarle Sound was formed by the drowning of that valley; and Core Sound was for the greater part of its length a southern tributary of the large river made up of the Pamlico and the Neuse, and passing to seaward through the present Ocracoke Inlet. The Albemarle River passed through the present fresh ponds just south of the Kill Devil Hills, and the margin of the continent was some three score miles eastward of its present position.

Then came the subsidence which drowned out the lower river valleys producing the estuaries and sounds already mentioned, and this subsidence may still be in progress in the region to the north of Cape Hatteras.

Since that subsidence, however, there has been an uplift of the land from Cape Hatteras southward, which, in all probability is still going on. As the dunes advance towards the sound side they depress by their weight the swamp muck in which the trees of that side grow, and these are left exposed on the seaward side when the dunes have passed. This compression of the muck, which is common from Hatteras Island northward, may easily be mistaken for subsidence of the land.

But on the land opposite Core Bank, successive strata of muck, filled with well-rounded wind-blown sands rise twenty feet above Core Sound at Atlantic. Kitchen middens, too, mark this line of elevated shore, the heaps being composed mainly of oyster shells with an occasional bit of broken

Indian pottery, and an occasional stone cleaver. Similar evidences of recent elevation have been observed by the writer at various points from Cape Hatteras to Cape Sable.

NOTE—This paper was presented, with lantern illustrations, before Section E, of the American Association for the Advancement of Science, New York, December 31st, 1906, and an abstract appears in *Science* N. S. vol. xxv, p. 297, Feb. 22, 1907.

NOTE ON ELECTRICAL AGEING OF FLOUR.

J. W. GORE.

The Alsop Process of Ageing flour was described in the Electrical World of December 8th, 1906, which is now in use in many mills in the United States and also in foreign countries.

The apparatus consists of a 500 volt Shunt Wound dynamo, with an induction coil in series with it, and an air pump.

The circuit is automatically broken at each stroke of the pump; the break is between two copper electrodes, and the resulting arc is drawn out until broken.

The air through which this flaming Electrical discharge passes is forced by the air pump through the flour as it comes from the mill.

A 1½ kw dynamo is sufficient for a mill of some 30 to 40 barrels daily output.

It has been the practice of millers and warehouse men for a long time to age fresh flour by storage, thus fitting it better for bread and yielding a higher grade product. By Alsop's process these beneficial results are obtained in a few moments.

The conclusion is that the active elements in the atmosphere which improve the bread making qualities of the flour when stored, are plentifully produced by the flaming discharge of Electricity between Copper Electrodes.

INDUSTRIAL AND SCIENTIFIC ASPECTS OF THE PINE AND ITS PRODUCTS.*

BY CHAS. H. HERTY, PH.D.

Consideration of the annual production of volatile oils shows at once the great preponderance of spirits of turpentine over all others combined. Each quart of spirits of turpentine represents approximately one year's output of this product from one tree. At least nine-tenths of the world's supply of this substance comes from our Southern States, for the production of which not less than one hundred and twenty millions of trees are annually subjected to turpentining. Two millions of acres of virgin timber are annually brought into operation to supply the place of exhausted timber. Millions of pines which have never been turpentined are felled each year by the mills in Mississippi, Louisiana and Texas. Every winter the entire turpentine producing section is swept by ground fires which destroy most of the seedlings, and thus make impossible reproduction on any large scale. The annual revenue from the naval stores industry can be conservatively estimated under present prices at not less than forty millions of dollars. Surely such a situation justifies and demands systematic experimental work in the hope of conserving this valuable native resource.

EFFECT OF TURPENTINING ON LUMBER.

The pine has a two-fold commercial value, first, as timber, second, as a producer of the oleo-resin, "crude turpentine."

*Reprinted from *The Chemical Engineer*, March, 1907.

For many years it was believed that timber which had been turpentined, commonly called "bled timber," was inferior to "unbled" for construction purposes. A thorough investigation of this question in 1893 by the Division of Forestry of the U. S. Department of Agriculture showed the fallacy of this belief, and now no distinction is made. Indeed in France timber from trees which have been turpentined is preferred for all purposes where strength and elasticity are demanded.

CRUDE TURPENTINE.

Previous to the last twelve years no systematic experiments had been carried out in this country on the production of crude turpentine. The records of the U. S. Patent Office as far back as 1869 show various inventions designed as substitutes for the "box," this being a deep hole cut in the base of the tree, having a capacity of about one quart and serving to collect the crude turpentine which flows from the scarified trunk above. None of these devices however gained permanent favor among turpentine operators. In 1894 W. W. Ashe, of the N. C. Geological Survey, began a comparative study of crude turpentine collected by the "box" system, uniformly practiced in this country, and by the "cup" or Hugues system, practiced in France. These experiments were planned with care, and although carried out on a small scale gave interesting results. They were discontinued after one year.

In the hope of accomplishing something toward the conservation of the pine forests of Georgia I began during the summer of 1901 field experiments on the production of crude turpentine by the pine. With an apparatus somewhat similar to that used in France, but essentially modified to suit our system of scarification or "chipping," various studies, both qualitative and quantitative, were made in the pine forests of the southern part of the State. Many of the specimens collected were afterwards examined in the chemical laboratory. The striking character of the results obtained aroused the interest of the U. S. Bureau of Forestry, and during the fol-

lowing winter I was led to accept a commission in the Bureau for the purpose of carrying out on a commercial scale the experiments already begun.

As introductory to the discussion of that work let me explain briefly the operations commonly in practice in the turpentine woods. During the winter the "boxes" are cut in the trees. In early spring the weekly scarification or "chipping" begins. It is necessary to renew this wound each week, as the flow of crude turpentine practically ceases after seven days. Chipping extends each year about eighteen inches up the tree, the depth of the cut being about one inch and the width, on an average tree, fourteen inches. When the boxes fill, usually every four or five weeks, the crude turpentine is removed to buckets, then to barrels and hauled to the still. During the year some of the product remains sticking to the exposed "face" of the tree. This is collected in the fall and distilled, although it has a much smaller percentage of spirits of turpentine than the "dip" from the boxes. Lastly a space around each tree is cleared of all combustible material as a protection against the annual ground fires.

The basis of my work was the conviction that the pine is not so much a store-house but rather a factory for the production of crude turpentine, and that timber which is not boxed should produce more than timber whose vitality is diminished by the cutting of the box. Comparative experiments were carried out in 1903 at Ocilla, Ga., on thirty thousand trees. In these experiments both the "box" and the "cup and gutter" systems were used under conditions as nearly identical as possible. The results showed an even greater difference in favor of the unboxed timber than was expected, while the qualitative results previously obtained by Ashe were confirmed. The immediate commercial introduction of the cup and gutter system was assured by the financial gain from the increased output, the improved quality of the rosin and the protection given to the trees against wind and fire.

For the production of crude turpentine it is necessary to

wound the tree. If the tree is girdled it dies. What then is the limit of wounding to which it is necessary to subject the tree in order to get the most profitable yield, and beyond which it is unsafe to go? It had been proved at Ocilla that the box was an unnecessary wound and that by its elimination the yield could be increased. The next step then was to make comparative tests bearing upon the extent of the wound given in "chipping." For the past two years such experiments have been conducted in Florida by the U. S. Forest Service, and by the courtesy of the Service I am enabled to tell you that results already obtained show that shallow chipping produces as much or eventually more crude turpentine than the customary deep chipping, while at least one year in three can be gained in the usual rate of ascent of the tree without diminishing the output. Still other experiments yielding most valuable results are in progress, all bearing upon more conservative wounding of the tree. None of these experiments are extreme, but all are rational modifications of present practices which will carry conviction when the details are published.

Of an entirely different character from the experiments just mentioned, but of great scientific and practical value, are the recent studies of Prof. A. Tschirch, of Switzerland, on resin secretion. By the use of the microscope and suitable stains he has proven that the seat of resin production is in a mucilaginous layer lining the inner walls of the resin ducts. In a later study, carried out upon a large number of trees, he has further demonstrated that while there are a limited number of "primary" resin ducts present in the untapped pine, by far the greater flow of resin proceeds from secondary ducts formed in the outer sap wood after the wounding of the tree. The resin from the "primary" ducts is a physiological product, that from the "secondary" a true pathological product.

While many chemical studies have been made of the products obtained by distillation of crude turpentine, only one detailed investigation is on record regarding the nature of the

oleo-resin secreted in the Longleaf pine. Tschirch and Koritzschoner have shown that this oleo-resin consists of

Palabienic Acid—$C_{13}H_{20}O_2$	5	per cent.
Palabietic Acid—$C_{20}H_{30}O_2$—	6	" "
α and β—Palabietiolic Acid—$C_{16}H_{24}O_2$—	56	" "
Spirits of Turpentine	20	" "
Paloresene	10	" "
Impurities, Bitter Principle and Water	3	" "

No study has been published of the oleo-resin from Pinus Heterophylla, or Cuban pine, which occurs so frequently in the Florida forests and from which therefore so large a proportion of the present supply of spirits of turpentine and rosin is prepared. Such an investigation has been begun in the laboratory of the University of North Carolina.

Many interesting new lines of investigation in this field suggest themselves if the chemist instead of waiting for specimens to reach the laboratory will study and note the changes at the tree. When the oleo-resin first appears it is a perfectly clear liquid. In the case of some pines it remains thus for weeks and then slow crystallization of the dissolved acids begins, with others the crystallization begins within a minute after the drop appears. Evidence already in hand points to the probability that the clear liquid issuing from the resin ducts is a supersaturated solution. To what is this condition of supersaturation to be ascribed? Again, the flow of resin is relatively rapid during the first forty-eight hours after wounding, then quickly diminishes and practically ceases after seven days. Is this cessation to be explained by the plant physiologist or by the chemist? Has the inner lining of the resin duct lost its power of production, or has the duct been closed by oxidation, or crystallization of the oleo-resin which it exudes? If chemical, can it be prevented by some simple means? A practical solution of this problem would be a great blessing to the turpentine operator in these days of scarcity of labor and would do more than anything

else for the preservation of our pine forests. Still again—what is the chemistry of "scrape" formation? Why the variation in the amount of scrape formed in pines of different species and even among those of the same species? These are a few of the many problems in this untouched field awaiting the skill and patience of the investigator.

DISTILLATION.

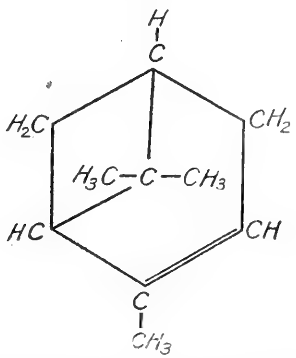
Crude turpentine is of very little commercial use. It must be separated by distillation into its constituents, spirits of turpentine and rosin. In this country distillation is carried out in large copper stills heated by direct fire. During distillation a current of warm water is let into the still. The steam produced by the water added during distillation materially lowers the temperature and lessons the time necessary for the complete removal of the spirits of turpentine. An interesting study of this subject from a physico-chemical standpoint has been made by Prof. Vezes, of Bordeaux. By distilling at this lower temperature the possibility of destructive distillation of the rosin is avoided. The vaporized spirits of turpentine and the steam are condensed in a water jacketed copper coil and collected in a suitable vessel where separation takes place owing to the difference in specific gravities and the mutual insolubility of the two liquids. On completion of the distillation the cap of the still is removed and the excess of water boiled off to prevent opaqueness in the rosin. The molten rosin is then run through an opening near the bottom of the still into strainers lined with cotton batting through which it filters into a vat. After partial cooling the rosin is dipped into barrels where it slowly solidifies.

During the summer of 1903 I had opportunity to study the systems of distillation practiced in France. Three types were found, first distillation by free flame and addition of water, as in this country, second by steam alone in steam jacketed stills, and third by a system of "mixed injection," i. e. free

flame and addition of water together with steam injection. The cost of a plant for distillation by steam alone is far greater than that of the simple plants in this country. After careful study of these systems I am convinced that if a skillfull "stiller" is in charge, as good results are obtained here as with the best of the French steam stills, but the personal equation, which plays no role in the steam still, is of prime importance with us. Perhaps the best of these for our conditions would be that of mixed injection, for the extra cost of installation and operation is not great and the personal element of the "stiller" is entirely eliminated.

SPIRITS OF TURPENTINE.

The chief constituent of spirits of turpentine is pinene, $C_{10}H_{16}$. Many battles have been waged over the structural formula of this compound. At first it was classified among the open chain hydrocarbons but later was shown to be a ring compound. Of the many formulas proposed that of Wagner is most in accord with the reactions of the substance.



Some of the work upon American spirits of turpentine has been in vain, because investigators failed to take into account the facts that in our turpentine orchards more than one species of pine is turpentined and that the crude turpentine from each is indiscriminately mixed when collected. Recognizing these

facts J. H. Long in 1893 secured specimens from identified individual trees, distilled the volatile oils from each and concluded that while American turpentine rotates the plane of polarized light to the right the variations in the amount of rotation in different specimens is due to admixture of the lævo-rotatory oil from Cuban pine with the dextro-rotatory oil from theLong leaf pine, and as the latter tree generally predominates the resultant oils are more or less dextro-rotatory. New light has been thrown upon this subject by an investigation carried on during the past year in the chemical laboratory of the University of North Carolina in collaboration with the U. S. Forest Service, by which the results of this study are to be published shortly. Through the courtesy of the Service I am enabled to refer to some of the results of special interest in this connection. During the past season, at regular intervals of four weeks, the crude turpentine has been collected separately from seven Longleaf and seven Cuban pines. A study of the oils distilled from these specimens has shown a marked variation in the rotation of polarized light. The variation exhibits itself not only in the oils from the two species of pines, but even among those from the same species. The Longleaf pines generally yielded dextro-rotatory oils. One, however, yielded a lævo-rotatory oil, while another scarcely affected the plane of polarization. The Cuban pines gave generally lævo-rotatory oils but through wide variations, one of them effecting only a very slight rotation. In the case of each tree, however, the rotation of its oil was found to be practically constant throughout the season.

The rapid rise in the price of spirits of turpentine during the past few years has led to frequent adulteration and the offering for sale of many substitutes. The producer, tempted by the great difference in price of spirits of turpentine and kerosene, has frequently mixed the two. The remedy was peculiar. Seeking to advance the price by producing less spirits of turpentine, the operators soon found that their successful effort to curtail had been fully off-set by the addition,

at many stills, of kerosene sufficient to keep the output at its former figures. The most prominent producers then led the fight for "pure spirits" laws and in the largest producing States effective legislation on this subject has been enacted. Similar laws have recently been passed in New York State.

Mineral oil constitutes the chief adulterant of spirits of turpentine. While such an addition may not materially lower the solvent power, it diminishes the oxygen carrying power directly in proportion to the amount present, since American petroleum is composed almost wholly of saturated hydrocarbons. So skillful has become the art of adulterating with petroleum products that detection by the ordinary physical tests can be evaded if the adulterant is not present in too great quantity. But by polymerization of the terpenes with concentrated sulphuric acid, Herzfeld's method, adulterations even as low as one to two per cent. can be detected with certainty. Especially is this true if after successive polymerizations the oils, distilled with steam, be examined with the refractometer, as recommended by McCandless.

No discussion of spirits of turpentine would be complete without embracing that form now legally designated as "wood spirits of turpentine." It is no new thing that a volatile oil, various heavy oils and charcoal can be obtained by destructive distillation of "fat lightwood." More than forty years ago extensive plants for such distillation were in operation in North Carolina. But the low price of spirits of turpentine made these financial ventures unsuccessful. A few plants continued operations on a small scale, but the matter dropped out of public notice for a long while. With the recent rise in price the subject was again agitated. By the aid of clever promotion, by the exhibition of actual results obtained, but from raw material above average richness, by frequent reference to latter-day success in saving and utilizing by-products and finally by that sweet vision of pestiferous stumps removed from the cotton rows, great enthusiasm was raised, and at one time unlimited capital was available for destructive dis-

tillation plants, provincially called "stump factories." Many were built, but it was soon found that the paint and varnish people did not want the product, as the quality was irregular and the odor bad. Then, too, the by-products so carefully saved found no market. Finally through faulty construction or careless management many of the plants burned. Consequently destructive distillation lost favor and plants were erected for the extraction from lightwood by steam of spirits of turpentine alone. This method gives an oil of good quality, and with increased experience a product is now manufactured which is practically the same as "gum spirits." But the yield from average raw material is rather low and if it be sought to increase the yield by elevation of temperature the quality is inferior.

I think I have stated the case fairly. We all hope that this industry will eventually be placed upon a good solid basis. Let me emphasize three points in connection with this subject:—

First.—Fewer promoters and more chemists would improve the situation.

Second.—Investors must not expect to realize the enormous profits claimed by some of the over-enthusiastic, but the business is capable of yielding fair dividends if the plants are properly located and carefully managed.

Third.—In spite of the preference now shown for steam extraction, the future of this industry lies in destructive distillation, but not as at present practiced. The difficulty of securing profitably a permanent supply of raw material will lead to the establishment of numbers of cheap stills. Such stills require no expert labor and can be easily moved from time to time to fresh portions of the territory for raw material. The crude product from these small stills will be shipped to central refineries where suitable apparatus will be found operated under the direction of chemists.

ROSIN.

What is rosin and of what chemical compounds is it

composed? This question has interested chemists for many years. The literature of the subject is very extensive and the views held at various times were and even now are widely different. By Maly and Flückiger rosin was considered the anhydride of abietic acid. Henriques contended for the presence of lactonic acids, Benedict for free acids and ethereal salts, Fahrion for sylvic acid, while Tschirch has recently separated from American rosin three isomeric acids α, β and γ abietic acids, and considers that all other workers in this field have been dealing with impure products. The controversy on this subject between Tschirch and Fahrion is not yet ended. Tschirch can not decide between $C_{19}H_{28}O_2$ and $C_{20}H_{30}O_2$ as the correct formula for abietic acid. Nor has it been determined with any certainty whether the oxygen atoms of this acid are present in the form of hydroxyl or carboxyl groups. It is possible that some of these differences may be due to the fact that many of the specimens used for investigations are so called "American Rosins," without taking into account the fact that much of this rosin is derived from at least two different species of pines, Pinus Palustris and Pinus Heterophylla.

Rosin varies in color from a pale yellow to a very deep red, the price of the rosin decreasing with increasing color. In France the better grades of rosin are placed in shallow trays and exposed for three or four months to the bleaching action of sunlight. Almost colorless grades are thereby obtained. This practice is carried on by one firm in this country. But sun-bleaching is not effective with the darker rosins. The great difference in price between the low and high grades has led to many efforts to devise chemical methods for bleaching rosin. A number of patents have been issued on the subject, but so far as I know none of these have proved commercially profitable. Here is a live problem for the chemist, the correct solution of which is certain to bring rich returns.

For many years the commercial demand for rosin was very

limited. Indeed at one time the price dropped so low that it was frequently the custom in North Carolina to distill the oil from the crude turpentine and turn the rosin into the creeks and swamps. In these latter days of higher prices the rosin from these dumping grounds has been dug up, melted, strained and shipped to market. The cause of this increase in price is not difficult to discover. It is the manufacture of rosin oil. Of the total amount of rosin produced about 10 per cent. is used for sizing, varnishes and other minor matters, 35 per cent., approximately, for soap making, while not less than 55 per cent. is subjected to destructive distillation whereby rosin spirits, various rosin oils, brewers pitch, etc., are obtained. As a substitute for or adulterant in linseed oil, as lubricants, in printer's ink and in many other ways rosin oils are finding wider and wider application. This industry thrives chiefly in Germany, to quite a large extent in England and Scotland, and a much more limited extent in France, where a high tariff prevents the importation of American rosin. In this country there are about three rosin oil distilleries, operated somewhat in the same manner as the European plants. Why should not this industry thrive in our Southern States? It would seem that the same logic which led to the recent movement to erect cotton mills near the fields of cotton would apply in this case also. We have a great advantage over the foreign manufacturer if we will only make use of it. When the German or English rosin oil manufacturer gets the rosin thoroughly melted in his still he is just at the point where we were at the moment the molten rosin was turned out of our turpentine still into the vat. Meanwhile what has happened? The heat stored up in the molten rosin has gone to waste, there has been added the labor of dipping it from the vat into the barrels, the cost of inspection, broker's commissions, transportation costs, labor in getting the rosin from the barrels and breaking it into lumps of suitable size for the still, and finally the cost of fuel for again melting the rosin, and why? All in order to get it

back again into the condition in which we once had it. Many industries have been developed on a much narrower basis of saving than that just indicated. Adjacent to each of our turpentine stills there should be found one or more for rosin oil, placed on a lower level, so that the molten rosin could be run directly from the one to the other and destructive distillation of the rosin begun. The stills for rosin oil being made of iron are not expensive and the skill required for distilling is far less than in the distillation of crude turpentine. Again, but little labor would be required, nor would it be necessary to find markets or uses for the products: these already exist and are constantly increasing. With such manifest advantage we should be able to locate the whole of this industry in our midst.

JOURNAL

OF THE

ELISHA MITCHELL SCIENTIFIC SOCIETY

JUNE, 1907

VOL. XXIII NO. 2

PROCEEDINGS OF THE NORTH CAROLINA ACADEMY OF SCIENCE, SIXTH ANNUAL MEETING, HELD AT CHAPEL HILL, MAY 17TH AND 18TH, 1907.

The executive committee met Friday, May 17th at 1 p. m., the following members being present: Collier Cobb, W. C. Coker, John F. Lanneau, and F. L. Stevens.

The following names were proposed for membership to the Academy and were elected to membership by the executive committee: Dr. C. H. Herty, Chapel Hill; Dr. J. H. Pratt, Chapel Hill; Dr. A. S. Wheeler, Chapel Hill; Dr. J. E. Mills, Chapel Hill; Dr. R. O. E. Davis, Chapel Hill; N. C. Curtis, Chapel Hill; J. G. Hall, West Raleigh; H. W. Smith; W. A. Withers, West Raleigh; Dr. G. A. Roberts, West Raleigh; F. P. Drane, Chapel Hill; R. T. Allen, U. S. Geological Survey; J. E. Pogue, Jr., Chapel Hill; Miss Daisy B. Allen, Raleigh; Louis W. Gaines, Wake Forest; W. N. Hutt, Raleigh; J. J. Wolfe, Durham; M. H. Stacy, Chapel Hill; Clifton D. Howe, Biltmore; C. W. MacNider, Raleigh: Will L. Brewer, Greensboro.

At 3 p. m. Friday, the 17th, the Academy was called to

Printed June 17.

order by its President, Professor Collier Cobb, and an address of welcome was extended to the Academy by President Francis P. Venable, of the University of North Carolina. A response to the address was made by the retiring President, John F. Lanneau, of the Academy of Science. The remainder of the afternoon session was devoted to the presentation of papers.

At 9 p. m. the Academy met in Gerrard Hall, and the presidential address, "The Garden, Field, and Forest of the Nation," was delivered by President Cobb Following this address a reception was extended the visiting members in the Y. M. C. A. building.

Saturday, May 18, at 9 a. m., the Academy convened for a business meeting. The minutes of the last meeting were read and approved, and the names of the new members, as elected by the executive committee, were read and formal vote of election to membership was made.

The nominating committee, previously appointed, presented for election the following names: President, T. Gilbert Pearson; Vice-President, W. C. Coker; Secretary, F. L. Stevens; members of the executive committee, Franklin Sherman, Jr., J. J. Wolfe, and John F. Lanneau. It was moved by F. L. Stevens that the name of E. W. Gudger be substituted for that of F. L. Stevens for Secretary. The amendment was carried. These nominees were then elected to office for the ensuing year. The report of the Treasurer, showing a balance of $122.53, was received. Raymond Binford and Franklin Sherman, Jr., were appointed as auditors. It was moved and carried that the executive committee be requested to hold the meeting next year two weeks earlier than that of this year.

Following the business meeting was held a meeting for the presentation of papers.

The following papers were presented:

1. The Sparsity of the Stars, the Measureless Remoteness of

each Star from All Others, John F. Lanneau, Wake Forest College.

The paper will appear in full in Popular Astronomy.

2. The Foundations of Geometry, Archibald Henderson, of the University of North Carolina, published in The Journal of the Elisha Mitchell Society, May, 1907.

3. Some New Sources of Light, C. W. Edwards, Trinity College. Read by title.

4. Some Interesting Grasshoppers (and Their Relatives) of North Carolina, Franklin Sherman, Jr., State Entomologist.

5. Osteogenesis Imperfecta (with a report of a case), Lewis M. Gaines, of Wake Forest College. Read by title.

6. Notes on the Cultivation of Algae for Class Use, F. L. Stevens, of the North Carolina College of Agriculture and Mechanic Arts.

Suggestions were given for the isolation and cultivation of algae upon solid medium, consisting of 75 per cent, ager made up with Knopf's solution. This medium solidifying at lower than 34 degrees, can be safely used in plating out algae. Cultures of several forms were exhibited.

7. Fusion of Sponge Larvae with formation of composite sponges, H. V. Wilson, of the University of North Carolina.

The ciliated larvae of silicious sponges (Stylotella) may be made to fuse, thus giving rise to composite sponges. To accomplish this result it is only necessary to bring the larvae in close contact at the time when the ciliary action is no longer locomotary and fixation is about to occur. The composite masses representing (in the actual experiments) from two to six larvae complete the metamorphosis.

8. Wind-polished pebbles, and Palaeolithic Man, Collier Cobb, of the University of North Carolina.

The close similarity between pebbles faceted and polished by the sand-blast and the implements of early man was indicated, and the errors which might result from superficial observation were pointed out.

9. Notes on the Zoology of Lake Ellis, C. S. Brimley, Raleigh, N. C.

The paper discusses the occurrence of various insects and reptiles taken by the writer and others in the vicinity of Lake Ellis, Craven County, N. C., during June, 1905, and May, 1906. The rare salamander, Stereochilus marginatus, which had not been taken for many years, was found to be common, and several specimens of the frog, Rana virgatipes, were taken. Nine alligators were secured on the two trips by the author's companion, and several rare snakes. Five species of dragon fly, new to North Carolina, were secured, and (in June, 1905,) numerous specimens of the yellow fly (Diachlorus ferrugatus). Notes on other members of the Tabanidae are also given.

10. Single Phase Railway Work, J. E. Latta, of the University of North Carolina.

11. The Relation of the Cattle-tick to Southern Agriculture, Dr. Tait Butler, State Veterinarian, Raleigh, N. C.

12. The Design of High Masonry Dams, William Cain, of the University of North Carolina.

The method of finding the resultant of the water pressure and the weight of masonry pertaining to any horizontal joint of a dam is given; also the decomposition of the vertical component of this resultant along the joint according to the usual hypothesis. The hypothesis of the conservation of plane sections, in the case of a battered wall, is then criticised and the resulting vertical unit pressure at a face of the

wall, shown to be too high and therefore on the side of safety. But since the pressure near a face, acts necessarily parallel to that face, the vertical unit pressure just computed, is not the whole pressure.

The difficulty of computing exactly this whole pressure is next entered into and an upper limit found by an approximate method which again gives an excess pressure.

Rankine's suggestion, to use the ordinary formula for vertical unit pressure, but specify higher limiting unit pressures for the up-stream face than for the down stream face is adopted provisionally.

The claim is made that, in addition to the three universally imposed conditions, no tension, safe unit pressures and no possible sliding at any horizontal joint—a fourth condition must be imposed, viz., that the factors of safety against overturning and sliding shall increase gradually from the base upwards to allow for the proportionately greater influence, on the upper joints of wind and wave action, floating ice or other bodies, and especially of the great forces caused by the expansion of thick ice under an increase of temperature and by earthquakes.

It was found that this could easily be done by taking the well-known theoretical triangular type of cross-section of dam and making some additions at the top sufficient for a roadway.

A preliminary design is given for a dam 258 feet high, with factors of safety and unit pressures marked on the drawing, satisfying all four conditions. The area of cross-section and height being the same as for the celebrated Quaker bridge design, a comparison was instituted, unfavorable to the latter, in that its factors of safety are too small, particularly in the upper portions, where by the proposed fourth condition they should be largest.

This criticism owes its significance to the fact that the new Croton Dam of New York, 224 feet high to water surface and finished February 1st, 1906, at a cost of over $7,500,000, has

a profile for 224 feet in depth, exactly the same as the Quaker bridge design for the same depth.

Engineering News for June 30, 1888, January 12, 1893, and May 9, 1907, is referred to for the destructive action of ice on ponds, lakes, and rivers, due to the expansion from an increase of temperature during the day. At night, contraction causes cracks to form, often several inches wide, which are filled up with new ice and thus the effect, from day to day is cumulative and very destructive as far north as Canada and in the Northern States. As yet, the action of ice on high dams has not received much attention.

For earthquake action on houses, Milne is referred to; also a personal experience of the author in Charleston, S. C., is recited. It was pointed out, however, that dams being built into the sides of the valley at their ends, were not so free to move at their tops as houses.

A brief description and analysis of the failure of the Habra dam concludes the paper.

13. Three Little Known Species of North Carolina Fungi, J. G. Hall, of the North Carolina Experiment Station.

14. A New Form of Achlya, W. C. Coker, of the University of North Carolina.

During the fall of 1906 an Achlya was found at Chapel Hill, N. C., which agrees with *Achlya racemosa*, var. stelligera Cornu, in many respects, but different from it in having the antheridum cut off immediately below the oogonium, and the fertilizing tube arising from the division wall and entering the oogonium from below, as in Saprolegnia hypogyna Pringsheim. Such an origin for the fertilizing tube is new for the genus Achlya, and is not known elsewhere except in Saprolegnia hypogyna.

15. Notes upon the Preparation of the Silicate Medium for the Cultivation of Bacteria, J. C. Temple, N. C. Agricultural Experiment Station.

Directions were given for the preparation of this medium obviating the necessity of dializing, and making it possible to prepare this medium with greater certainty and greater accuracy. The use of the medium prepared in this way for the culture of various organisms was illustrated by colonies of various bacteria growing in a thriving condition upon the medium.

16. Breeding Colonies of Birds (Illustrated with Eggs and Stereopticon views), T. Gilbert Pearson, of Greensboro.

17. The Efficiency of Soil Inoculation in the Production of Root Tubercles, F. L. Stevens, of the North Carolina Agricultural Experiment Station.

Data was given concerning the inoculation of soils with liquid cultures obtained from the Department of Agriculture, Washington, D. C. From many tests conducted in various ways there was no evidence whatever that inoculation with these cultures was efficient in the production of tubercles upon the legumes. The cultures employed were issued in liquid condition in hermetically sealed test tubes, and were obtained directly from the Bureau of Plant Industry, Washington, D. C.

18. The Opportunities for Study and Research at the Beaufort Laboraty, H. V. Wilson, of the University of North Carolina.

19. Does Blood Tell? Heredity According to the Experience of the Children's Home Society, William B. Streeter, of Greensboro, N. C.

20. Geology of the Cape Fear River, Joseph E. Pogue, Jr., of the University of North Carolina.

21. The Relation of Sporangium of Lygodium to the Evolution of the Polypodiaceae, Raymond Binford, of Guilford College.

22. The Condensation of Alipatic Aldehydes with Aromatic Amines, Alvin S. Wheeler, of the North Carolina University.

The following reaction takes place without any dehydrating agent: $RCHO+2RNH_2=RCH(RNH)_2+H_2O$. In some cases at low temperatures the addition product is obtained. Condensation products of Chloral with the three nitranilines, p-bromaniline, o-toluidine, anthranilic acid, and o-anisidine were prepared. By-products, as yet unidentified, were obtained with o-toluidine and with anthranilic acid. The condensation products are readily broken down by Hydrochloric acid and by acetic anhydride. When suspended or dissolved in the glacial acetic acid they react with extreme smoothness with bromine, forming beautifully crystalline compounds which are much more stable than the condensation products.

23. Chapel Hill Ferns, by W. C. Coker, of the University of North Carolina.

A collection of the living ferns and fern allies native to Chapel Hill, N. C., was made and exhibited in pots. Twenty species were represented, including all the known Ptridophytes of the neighborhood, except Botrychium ternatum and its variety, dissectum, which had not yet appeared above ground.

24. Notes on Turtles of Genus Pseudemys, C. S. Brimley, of Raleigh, N. C.

25. Electricity in Heavy Traction (Illustrated by lantern slides), J. E. Latta, of the University of North Carolina.

26. The Optical Rotation of Volatile Oil, C. H. Herty and G. A. Johnson, of the University of North Carolina.

27. Children's Home Society Methods, William B. Streeter, of Greensboro.

28. Gametophytes of Botrychium Virginianum, Raymond Binford, of Guilford College.

They were found in moist oak woods under the leaves. Some were almost on the surface of the soil while others were imbedded one to two inches in the soil. They seem to have gotten down by means of worm holes or cracks made by roots of trees. Sizes ranging from 2 m. m. to 10 m. m. were shown. Specimens of these plants were exhibited before the Academy.

A motion of appreciation of the courtesies extended to the Academy by the members at Chapel Hill and ladies of Chapel Hill was unanimously carried.

At 1:30 o'clock Saturday the Academy adjourned.

F. L. STEVENS, Secretary.

THE GARDEN, FIELD, AND FOREST OF THE NATION.

BY COLLIER COBB.

(Address as President of the North Carolina Academy of Science.)

It has been the boast of more than one of our politicians that North Carolina could well be independent of the rest of the world, for we might enclose the State with a high wall and get along just as well, since we produce within our borders everything that we need. This boast was based on the fact that North Carolina puts something in every column of the blanks sent out by the Agricultural Department at Washington, that she produces a little of everything; but the inference drawn from this fact is far from being true. Not a single county in the State produces food-stuff sufficient to sustain its population. As our towns and cities have grown, the relative food production has diminished, and in most of our counties this diminution in the amount of food produced has been not only relative but absolute.

For the last score of years the population of our towns and villages has increased as families have gone from the farms to the factories, often to live off the labor of the children, or from the rural districts to the city in order to give the children better schooling. The increase of our population from outside sources, too, has helped to swell the urban population. But farm lands are not increasing, the acres planted with food stuffs have steadily diminished in number, and under our old system of cultivation there has been a steady diminution in the value of the returns per acre. Even

Orange County, which may be reckoned a rural district, does not begin to make food enough to maintain its inhabitants through the year, and the inhabitants of our adjoining county of Durham would starve in less than a fortnight if they had to depend on the food product of the county for support. When some of us in this hall came to college the village of Durham could claim no other distinction than that of being the railway station from which students drove to Chapel Hill. Today it is a city of more than 20,000 inhabitants, drawing its population from all parts of the world, and dependent upon distant fields for its support. And not one of our large cities, Wilmington, Charlotte, Asheville, Greensboro, or Raleigh, could depend on its own county, or even upon the surplus of a score of adjoining counties, for its food.

Notwithstanding the several years of unprecedented crops that we have had, amounting almost to seven years of plenty, we are practically face to face with a famine. The wheat lands of our own Northwest have been practically exhausted of their lime, as an acre of wheat will use up ten pounds of lime in coming to maturity; and this loss, added to the damage done the soil by the poisons excreted by the roots of the wheat, has caused our farmers of the great plains to seek new fields in the Canadian West. Already the natural pasturage of our semi-arid regions has been practically exhausted, and neither cattle-raising nor sheep-raising is profitable, where within two decades vast fortunes have been made in these industries. Those of you who paid your month's butcher's bills on the first of May were doubtless led by their unusual size to investigate causes, and learned that for the first time in the history of the Chicago and Kansas City packing houses they have not been able to fill their cold storage. The demand of the country for fresh meat has consumed the entire output of these houses during their busy season. And this state of things has come about after three years of abundant crops, during which time the packing

houses have paid their own prices for meat. Now let a drought come and there is absolutely no escape from a meat famine.

But what are we going to do about it? What is the solution of the problem? We are all familiar with the fact that in our older States of the South the annual product per acre has greatly decreased, owing to the rapid loss of soil fertility, and that even our moderate production is maintained only at increased cost; and also, that the comparatively new States like Texas, as well, show a rapid deterioration of land and loss of fertility. And it may be pointed out that our farmer is of all men most miserable; neglected and looked down upon; slave to the credit system; servant where he should be master; poor and becoming poorer; the prey of sharpers; the disconsolate follower of a calling which he has inherited with his deteriorating acres, clinging to the past, knowing no higher law than chance, planting, rearing, and gathering his crop under the leadership of luck, each succeeding year seeing his granary heaped fuller of disappointments, leaving him poor in purse and lean in hope. None of us can deny that this is a true picture of the average farmer of our State as we have known him from our youth up. The politician who has flattered him biennially that his calling, seen in its true perspective, is outranked by no other in power, scope, or service to mankind, has gone his way and made laws directly opposed to all the farmer's interests.

Still, what are we going to do about it? How are we to escape famine if our present source of supply should be exhausted? What is the solution of the problem? Increase the output from the soil that we have by the application of science—"that sensible science of our day which has for its ultimate aim not merely discovery but application; which is not so delighted by the formulating of a new law as it is overjoyed at the lifting of a burden;" science, in which laboratory investigation goes hand in hand with field experimentation, the science of our present time, which is applied

common sense, combining laboratory practice with business-like methods. Such science our United States Department of Agriculture is engaged in and encouraging; so also the various State agricultural experiment stations and most of the agricultural colleges, corn breeders' associations, truck growers' associations, sugar producers, tobacco growers, private investigators like Luther Burbank, all laboring to lift the burden from the agriculturist, and make him indeed what the politician has been flattering him that he is. Greater progress has been made in all departments of life dependent upon the soil in the last score of years than in the previous two score centuries.

The most important of all this service of science to the farmer bas been the study of the soil, the fundamental factor in all the varied lines of life that branch out from agriculture. How to save it, how to nourish it, how to restore it to life when dead, what it is composed of, how it is formed, how to interpret it so that any man may understand it—these have been, and still are among the great problems before us. Their solution is being worked out and already that work has revolutionized agriculture within our own State and is slowly changing conditions for the better in the entire South.

Tobacco is grown in eastern North Carolina today because a soil investigator found out that the marls just beneath the soil there contained in available form the lime that the tobacco plants require for their growth, and of course all the other essential minerals are there. Hitherto tobaccos had been grown on limestone soils, or on soils derived from igneous and metamorphic rocks rich in lime-soda feldspars.

In a similar manner it was discovered that the sands of the sand-hills regions of the Carolinas contain both lime and potash in available form, whereas similar sandy soils of Western Europe are practically devoid of these necessary plant foods, but this soil is particularly adapted to the growth of the vine, and in consequence an important grape industry has grown up in our sand-hills district.

Similarly it was found out that certain incoherent white quartz sand in Florida was valuable pine-apple soil, notwithstanding it was over 99.5 pure quartz, because it possessed certain properties that the bacteriologist discovered.

Investigation showed that the soil of the Connecticut Valley, which produced only low grade tobaccos, sneered at as Connecticut cabbage leaf, was essentially the same as that which produced the Sumatra tobacco. But it was necessary to change the climatic conditions, and this was done by the use of cheese-cloth, increasing the humidity and raising the mean temperature ten degrees Fahr. Somewhat similar experiments have been tried in Darlington District, South Carolina, the result, so far as the production of Sumatra wrappers was concerned, being entirely satisfactory. And such investigations and experiments have been carried on all the way from Connecticut to Alabama and Texas with the result of greatly improving the product and greatly increasing the output, producing in the Southern States the cigar tobaccos of all lands.

This matter of the investigation of soils is by no means new, though its methods and their application to agriculture are matters of little more than a decade. Such investigations were begun by Liebig at Giessen more than half a century ago. He and his assistants made countless analyses of the ashes of plants. These showed the presence of different minerals in every species, that each species requires from the ground the same class of salts, and hence that it must sooner or later exhaust the supply of these salts in a given plot, and render it unfit for the growth of the species in question unless fresh supplies are provided.

"Liebig attempted to give the necessary supplies in the form of 'Mineral Manure', and soon set to work to study practically the effect of mineral manures on a large scale. In the year 1845, previous experiments in a garden having proved unsatisfactory, he purchased from the town of Giessen about ten acres of barren land—a sand pit, as he says, which

surpassed all the land in the neighborhood in its barrenness for ordinary cultivated crops; in the year this land hardly grew so much fodder as would have sufficed for a single sheep. It consisted partly of sand, partly of coarse quartz and pebbles, with strata of sand and some loam.

"Some of the soil was first tested by sowing it with seeds in pots after enrichment with some single mineral manure, with the result that not one of the plants got beyond flowerering; this showed that the soil was bad enough for his purpose of testing the value of minerals as manure.

"A number of mineral manures were then prepared for him according to prescriptions based on his analyses, and these were spread over the land; next he sowed on different subdivisions of it wheat, rye, barley, clover, potatoes, turnips, maize. In some cases he added sawdust to the manure, and in one case he used stable manure; otherwise no ammoniacal manure and no mineral matter was employed, except that to one plot he applied some forest soil and to another a mixture of forest soil and mineral manure. Even in the first year he had a harvest; the best results were given by those plots in which mineral manures were mixed with forest soil or stable manure. This, as he says, enabled him to correct his earlier ideas of the functions of humus, which by its decay renders an extra supply of carbonic acid gas to the plants that is especially valuable at the early stages. Gradually, without any other supply of manure except mineral manure, the land so improved in productiveness that in the fourth year his crops excited the wonder of all who had known the original state of it.

"In 1849 this little farm was purchased by his gardener, who was then able to farm it with profit, raising some cattle on it yearly and getting such satisfactory crops of corn that in 1853 a neighboring farmer wrote: 'With us the wheat crops are very poor, but on the height (Liebig's plot) they have harvested three fuder of rye twelve simmer, while I from three fuder of the best rye, have only got five simmer.

If you were to see it, you would be astonished; it is truly wonderful.' "

From his experiments with this land Liebig was led to form the opinion that it was possible, by giving the soil proper physical quality and composition, to bring about a state of things in which sufficient ammonia to maintain its fertility can be collecteed or condensed from the air. He recognized not only that certain elements were necessary in a fertile soil, but more—and what certain soil chemists have been slow to recognize—that these elements must occur in certain combinations as minerals to be available as plant-food. He found, too, that certain earths and other substances might be added to soils, which would withdraw to some extent soluble salts from their solutions, removing from the soil substances injurious to plant life. Liebig was greatly interested in the experiments made in England by Sir Thomas Way on the absorptive power of soils, and was the first to recognize the true value of these experiments to agriculture.

Thus it was that a chemist sixty years ago recognized that the study of soils was as much the province of the geologist, the mineralogist, and the physicist, as of the chemist; and the work with which he is credited in Denmark shows that he also regarded it as within the province of the botanist. So greatly did he value the structural features and mineral composition of a soil as indicators of its fertility, that he said: "In matters of this kind the farmer must pursue his own course.............he must not put the least faith in the assertion of any foolish chemist who wants to prove to him analytically that his field contains an inexhaustible store of this or that nutritive substance."

In other words, Liebig saw that it is not so much the chemical elements in a soil as their mineral combination which determines their available plant food, and the geologists have found that very different rocks may be made from the same molten magma under different conditions of cooling. And it was Liebig who pointed out to the farmers that they

might change the fertility of their soil by changing its texture. In examining into the improved conditions of agriculture in the dune districts of the Jutland Peninsula a number of years ago, I found that the farmers of that country attributed their prosperity wholly to the suggestions made to their fathers and grandfathers by Liebig who went to Denmark to study moving sands; but I have not been able to find that he ever published anything on the subject.

But the dream of Liebig is being realized, and the study of soils is enlisting the closest attention of the chemist, the geologist, the mineralogist, the bacteriologist, the botanist,—a relatively small but powerful coterie of men who are the investigators and interpreters of modern agriculture. The chemist has found the essential plant foods, the geologist has noted the natural distribution of vegetation with relation to rocks both as to composition and structure, the mineralogist and geologist have studied the rock-making minerals in relation to their available plant-foods, the bacteriologist has shown us that certain living organisms in the soil are of enormous importance to every man who raises food for man and beast, the botanist has busied himself with breeding certain plants adapted to certain soils. "Knowledge is now no more a fountain sealed." The farmer of to-day may, nay he must, come up to his calling "as fully equipped for service as the lawyer, the editor, the doctor, the captain of industry; for the curious fact has developed that the calling in which the unlettered and untrained man was once supposed to have as good a chance as the educated one, is now the calling in which wide and varied knowledge is almost as imperative as in almost any other known among men."

Of the more than seventy elements that make up the crust of the earth only about a dozen are essential to successful agriculture and practically all soils contain these in one form or another. Only four of the twelve—nitrogen, phosphorus, potassium, and calcium—are liable to be lacking in

any given soil. But when any one of these four is wanting dire results follow.

The results that may be obtained, even where all these elements are present in proper proportion, depend upon the size of the soil particles, upon the number of grains of soil in the little measure of a gram; for the freedom with which the film of soil moisture moves over the soil grains determines the amount of plant food taken out of the soil. If the farmer is a raiser of truck for the early market, the soil for his lettuce, peas, beans, onions and radishes must be of a certain well-defined structure—it must have at least one billion, nine hundred and fifty millions of particles in a gram, in less than a thimbleful of earth. If he is going in for ordinary summer and autumn vegetables, corn and cabbage and potatoes, then there must be at least two billion additional particles in each gram of soil. If he is a wheat planter he must be sure that there are not less than ten billion, two hundred millions of particles in his little thimbleful of soil; while for wheat and grass land combined the soil must be in finer particles still.

While it has been known for at least two centuries that bacteria exist in the soil, it is only recently that they have been studied with any degree of satisfaction. They exist everywhere in earth and air and sea. They were believed at one time to have animal life, but they are now almost universally accepted as low forms of vegetable life. Over a thousand different kinds are now known, and the list is being steadily added to as knowledge of them increases. They increase by dividing themselves in two, and this they do at a marvelous rate of progression. One of them, according to a bacteriologist who has studied it closely, would, if left to itself, produce seventeen million descendants in twenty-four hours. Another scientist calculates that another particularly rapid multiplier could produce, if it had penty of food, four thousand seven hundred and seventy-two billion progeny in a single day. They differ from plants which we see growing

about us in that they have no chlorophyl—the material which gives the green color to the plants.

In a Kansas soil it was found that there were as many as one billion, six hundred and eighteen million, six hundred and eighty-one thousand, eight hundred and ten bacteria in a single gram or small thimbleful from a field under examination, while another field nearby had only a few over a million. As air is necessary for their existence, they rapidly decline in numbers as you go down in the soil to a point where none is ever found.

Many different families of these bacteria live in the earth, making their homes in the soil. They help to decompose it, thus transforming it into food. They draw vast stores of food supplies from the air. At every point they act as agents in advancing the interest of man.

Four-fifths of the air we breathe is one of the most valuable plant foods, nitrogen. Some of this nitrogen is available in one form and some in another, but it must all be put into such form that it may pass into the system of the plant and be utilized in the building up of stalk and leaf and ripened seed.

In portions of North Carolina I have seen a field worn out by injudicious cropping, the plants struggling to grow in a depleted soil into what would be at best but a lean and starved maturity. In an immediatly adjoining field, with a soil of precisely the same character, with no advantage in point of moisture, heat, or sunshine, with precisely the same kind of seed planted as in the first case, were tall, strong, and thrifty plants, neighbors to the thin, yellow, beggarly ones of the first field.

The only difference between the two was that when the seed were planted there was sprinkled in the rows of one field some plain simple dirt brought from another State, and the field that had this dirt sprinkled in its rows was the field with the strong and vigorous plants. What wrought the wonderful change was a colony of nitrifying bacteria, living,

moving things, that helped the crops to get their nitrogen from the atmosphere. Long ago it was discovered that certain plants, as the beans, clovers, peas, vetch, alfalfa, and the like, form upon their roots little bunches of tubercules, as they are called. When science sought out the meaning of these tubercules, why they formed on these particular plants, what purpose they served, it was seen that they were not abnormal, but necessary, and that plants that had them were more thrifty than those that had them not. It was discovered that their task was to take nitrogen from the air and transform it into nitrogen suitable to be taken up by the plant.

Having learned, then, the soil conditions necessary for plant growth, the next thing is to apply them.

Residual soils, those found upon the rocks from which they are derived, have certain definite characters determined by the characters of the rocks beneath, and they are not apt to deteriorate, since their source of food-supply is immediately at hand, unless the fine particles are carried away by erosion faster than the rock beneath can rot into soil. Transported soils, on the other hand, are very readily exhausted, since they are far removed from the parent rock, and they need to have their supply of plant-food constantly replenished by the use of fertilizers. One way of keeping up the fertility of the soil is by rotation of crops requiring different plant-foods.

The best way to farm is to plant in each field the crop to which the soil of that field is by nature best adapted.

But we often desire, or actually need, crops to which the soil of a given district is ill-adapted. Since we cannot change the soil materially, the difficulty is met by breeding plants to suit the soil, and what has been accomplished in this direction is little short of miraculous.

The wasting of soils where serials are grown, and the gradual reduction, year by year, in the yield of these crops, has led more than one thoughtful student of human condi-

tions to predict a time, and that not very far distant, when there will not be bread enough to go around.

While enough has been done in the restoration of worn out soils to show that the time is farther away than was at first feared, much more has been done in the breeding of new varieties of wheat and corn to take the place of the old and unsatisfactory ones. New wheats have been created not only showing larger yields and as great nutrition in experimental plots, but in the thousand-acre farm of the advanced American Agriculturist as well. More than this, wheats have been bred to fit a climate, redeeming vast areas of abandoned land supposed to be wholly unfit for wheat production.

New corns have been created, far richer in food values, far larger in yield, than the best known types of the past. More than this, corns have been created at the command of man for any one of a series of specific purposes—to be rich in one element and lean in another, to be food for man or food for beast. They are, in a word, as much the creation of man as the beautiful vase in the hands of the potter.

The experiment station of the University of Tennessee determined to breed a wheat that should fit the soil and climate of that State, where no wheat would grow and produce good results. When the experiments were begun, eight bushels to the acre was a fair average yield. After several years of testing, breeding, and selection, they have produced a wheat that has produced as high as forty-eight and one-half bushels per acre on the same land, while maintaining an average of over thirty-seven bushels for a period of four or five years. And we in North Carolina have reaped the benefits of this and similar experiments elsewhere in the extension of wheat producing area to the poorer lands of the eastern part of the State.

When we consider corn, the greatest cereal in point of value of annual production in the United States, the results achieved are even more satisfactory. The object sought in breeding new corns was not only to produce corn with a heavier yield,

but to change the character of the corn itself. Corn for human food should be rich in one element. Corn for manufacturing into any of the various products which are now made from it should be rich in certain other elements.

So the corn kernel was studied in order to find out precisely what it was made of, that by selective breeding this might be changed. By taking kernels from a series of ears known to be rich in one particular element, and breeding from these ears year in and year out, carefully selecting for future seed only the richest and best kernels and only those approaching the ideal established, little by little, with infinite pains and patience, new corns have been built up having the desired character and composition.

A manufacturer desires corn for the production of oil, now one of the most valuable products of the corn plant. It is in large demand among the olive-oil manufacturers of Europe. The oil comes from the fat in the tiny germ of the corn, and the larger the germ the greater the supply of oil. Corn-oil is in demand for many other purposes, and it appears to be but at the beginning of its commercial life. Hopkins in Illinois has succeeded in producing a corn relatively much richer in oil than any that has preceded it, one having 6.96 per cent. oil while the corn with which he started only six years before contained only 4.7 per cent. of oil. To some manufacturers the fat of the germ is not essential, so, to accommodate these, he reversed the process and bred a corn low in fat or oil, reaching 2.99 per cent.

The element of the corn which is most valuable for strengthening food, which is the muscle-building material of all food, has also been increased at will, and where it could make way for some other element suitable for some other purpose, it has been decreased. All this has been accomplished by selective breeding. Corn has been produced having 16.11 protein, a remarkably large amount, while the protein has been reduced to 6.66 per cent., a difference in protein of nearly ten

per cent. Corn is also bred for a large amount of starch, and similarly useful results follow.

The breeding of corn has gone to yet another extreme, the breeder having succeeded in doing away almost entirely with the grain and producing a large, firm cob. These cobs, that are produced on some of the poorest land in Missouri, are used for making the corn-cob pipe, and the introduction of the Collier corn into that district has been a Godsend to the poorest farmers with the poorest lands in the State. A very similar result has recently been obtained in Illinois, where a large firm cob with an insignificant grain has been produced on a soil of nearly pure siliceous sand. It has been found that the pith of the corn cob is a most valuable substance for calking ships and stopping leaks, the pith absorbing water and swelling to fill the crevice, and corns have been produced with a maximum of pith in the cob.

The corn of our mountain districts is rich in fat, and there too is the only portion of the South where we may raise sugar corn with success. The longer season in the lowlands admits of the elaboration of the fats into proteids. It is interesting to note in this connection that the corn of our mountains and the corn of the north are rich in heat producing elements, while these are almost entirely wanting in Southern varieties of corn, the long growing season admitting of the change of the sugars and fats into proteids. We cannot even raise sugar corn in our coastal plain from the seed of sugar corn grown there, but must get our seed each season from a colder region. The same is true with regard to the seeds of cabbage grown in the South except in the mountain region.

The changes in the character of corn are in no small measure the work of members of the corn-breeders' association, and show what may be accomplished through co-operation among farmers. This association has been working to make corn a complete ration. Here in the South, Williamson has greatly improved corn both as to quality and yield per acre, by a method peculiarly his own. The seed has been planted

and allowed to grow with grass and weeds until the plant has reached a weak maturity and is just ready to bear grain. Then the grass is cleared out, the corn well worked and heavily fertilized, when its stimulated growing energy goes all to fruiting. It has its parallel in the intellectual activity of the boy who comes from the back districts where he had no advantages of an intellectual sort, but his energies being aroused at the right moment, often surpasses his more fortunate associates in his college course and in the race of life.

Some of the most interesting experiments in plant-breeding have resulted in the production of food stuffs adapted to semi-arid regions, and these are of especial interest to us for the reason that we have a long strip of semi-arid land in the South, lying mainly in the sand-hills region and immediately bordering that region on the northwest, little more than a barren sand-waste until the introduction of new methods and new plants suited to its conditions.

Alfalfa has been bred to resist both drought and alkali, and it has also been found in nature. Agents of our Agricultural Department searched the earth for what was needed, and found just the thing desired growing in an oasis of the Algerian Sahara. Luther Burbank has bred a spineless and edible cactus admirably adapted by nature to such regions, and this may yet become an important food plant in certain portions of the South.

Rice forms the principal food of one-half the population of the earth. It is more widely used as a food stuff than any other cereal. Where dense populations are dependent for food upon an annual crop, and the climate admits of its cultivation, rice has become the staple food. The luxuriant growth of leguminous plants (peas, beans, etc.) in warm climates provides the nitrogenous elements necessary to supplement rice. A combination of rice with legumes is a much cheaper complete food than wheat and meat, and can be produced on a much smaller area.

The Carolinas in the decade ending 1860 produced approxi-

mately eighty-five million pounds of clean rice. Now the total product for a like period is only about thirty-five million pounds, of which North Carolina only produced about seven million. But the total rice product of the entire South has advanced from 103 millions to 143 millions in the same time, thanks to the valuable investigations of and improved methods introduced by Dr. S. A. Knapp, of the United States Department of Agriculture.

Horticulture is coming to be a most important branch of agriculture, and its surprising progress has already been so fully discussed in our newspapers and periodical literature that I need do little more than advert to it here. Suffice it to say that in 1870 the export of fruits preserved in cans or otherwise from the United States to foreign countries amounted in value to $81,735.00. Ten years later the value of the canned fruits exported had advanced to $371,118.50. In 1890 it was over $600,000.00, and in 1900 had passed two millions. This does not give us any indication of the enormously increasing domestic consumption of fruits.

It is an interesting fact that the traveler of to-day does not find his way across the desert by the bones of men and beasts that have started on the perilous journey before him, but by the shining tin cans left by those who have made the journey in safety.

This progress in fruit growing has been made possible by the breeding of fruits to suit different climates, and by the importation of insects to prey upon the insect enemies of fruit trees.

Already our trucking interests have made the South the garden of the nation, for we have here the broad coastal plain soils that yield readily to cultivation; but business methods have gone hand in hand with the application of scientific methods and are always equally important to the agriculturist. The managers of the truck-growers' association see to it that the crops come on in regular rotation from Florida, Georgia, the Carolinas, Virginia, and Delaware.

The Strawberry Trust at Selma, a North Carolina organization, has an agent who gets each night reports from all the strawberry eating cities as to the number of crates of berries on hand, and he then learns from the fields how many they can supply, and an effort is made to keep the shipments just a little short of the demand. Then by uniting their shipments and sending them forward in carload lots, the shippers get a better rate and quicker transportation.

Notwithstanding the South produces so much rice, and the entire product of the country, still we produce only half of what is consumed in the United States; but with the improved methods of cultivation, it will be but a short time before we produce enough for the entire nation.

Of corn we can produce every variety from our coastal plain to our mountains, and corn culture is extending about as rapidly as the culture of rice. The culture of wheat is extending as new varieties are being bred for our lands, and wheat culture is extending into regions where wheat has never before been raised. New varieties of potatoes have been produced in our potash soils, and already the best of these are grown in the South, and the rapid extension of their culture will soon make us the most important potato producers in the country.

Of cotton, we have not simply the monopoly of this country, but practically the world's monopoly as well. Experiments carried on at Darlington, S. C., have resulted in the production of a long-stapled cotton that will grow far from the sea islands. And the new methods ot tobacco culture are showing us that we can produce all the grades of tobacco, and these in any quantity.

Thus we already have the garden of the nation; we may become, nay, are rapidly becoming the nation's field for the production of food stuffs; and whether we will or no, we will soon be the only forest that the nation has left, except in the national forests scattered over our broad domain.

Forest trees depend more directly upon rock composition

and geological structure than any other products of the soil. This is beautifully illustrated in our State where conifers predominate over the coastal plain and sand hills region, and the broad-leaved deciduous trees over the granitic and schistose rocks farther west. Within these areas species and varieties vary with the changes in character of the rock and the change of its dip helping or hindering drainage. This is beautifully illustrated in the neighborhood of Chapel Hill, where our Triassic sandstones bear the loblolly pines, except where the rocks are cut by dikes, and then you may trace the dike by the broad-leaved trees that grow upon it. The crystallines of the Chapel Hill mass have their characteristic diciduous species, and these again vary as the rock structure changes.

We have in the Appalachians practically the only hard wood forests on the continent, and many of the most valuable species are confined to the Southern Appalachian mountains. In the north these forests have been ruined by the destructive work of the lumberman, before the introduction of the methods of modern scientific forestry; but here we already have the forest of the nation if we will but preserve it, and upon its preservation depend the field and the garden.

Our fathers had a true instinct when they pictured a great civilization in the South based upon the soil. Their vision is to be more than fulfilled when Southern agriculture can bring to its aid science, that sensible science of our day, which has for its ultimate end not merely discovery, but application; which is not so delighted with the formulating of a new law as it is overjoyed at the lifting of a burden. "Then the tiller of the soil will come up to his calling as fully equipped for service as the lawyer, the doctor, the captain of industry; for it has come to pass that the calling in which the unlettered and untrained man was once supposed to have as good a chance as the educated one, is now the calling in which wide and varied knowledge is as imperative as in almost any other known among men."

Men have also come to the same views as those expressed by the King of Brobdingnag, who "gave it as his opinion, that whoever could make two ears of corn, or two blades of grass to grow upon a spot of ground where only one grew before, would deserve better of mankind, and do more essential service to his country, than the whole race of politicians put together."

And better still: While the politician of the not very remote past flattered the farmer and yet made laws directly opposed to all his interests, the new politician in the South shows constructive statesmanship by helping him to take advantage of the opportunities around him, helps him with his inland waterways, helps him to preserve his forests.

SOME INTERESTING GRASSHOPPERS (AND RELATIVES) OF NORTH CAROLINA.

BY FRANKLIN SHERMAN, JR.

The grasshoppers and their relatives comprise the order of insects known as the Orthoptera. The entire order contains probably about 150 species native to North Carolina, of which about 130 have now been collected, identified, and recorded.

There are not many students of Orthoptera in this country and what few entomologists there are in the Southern States have neglected the group entirely, hence practically nothing was known of the actual distribution of our species until 1903, when Prof. A. P. Morse, of Wellesley College, made a special tour through the Southern States to study this subject, and, partially through the entreaties of Mr. C. S. Brimley and the author, he devoted more time to North Carolina than to any other State,—traversing it from east to west and then again visiting the high ranges in the western section. During his tour, Prof. Morse spent two days at Raleigh, at which time Mr. Brimley and the author accompanied him in collecting jaunts with the result that our latent interest in this neglected order was considerably aroused. The facts set forth in this paper have, therefore, for the most part, been collected in the last three or four years, by C. S. Brimley, G. M. Bentley, and the writer.

While no one can seriously study this order of insects without becoming interested in the special structures and their use in classification, as well as in the habits of the living insects,—yet there are about a dozen species which would more particularly arouse the interest or curiosity of the ordin-

ary observer, and to mention these is the special object of this paper.

Labidura riparia. This insect belongs to the family of insects known as the "Ear-wigs". The group is abundantly represented in Europe, but only sparsely in America, the few American representatives, however, being more especially distributed in the Southern States. Most of our ear-wigs are of small size, ranging from one-half to three-fourths of an inch in total length. In mid-April of the present year a janitor brought to the office a living specimen of this species, a fine large male, the first to be taken in the State.

Cryptocercus punctulatus. This insect belongs to the family of roaches, a few species of which infest houses, though more are found in the forest. The present species has been taken in four localities in this State, three of which are in the mountains, the exceptional locality being Newton. It is rather a large species, is entirely wingless, and is rather slow and stiff-bodied in movement, in which respect it differs from most other roaches. Our specimens have all been found under logs, in the months of July, August, and September.

Stagomantis carolina. This creature is most commonly known by the names of "Rear-horse", "Devil's Riding-horse", "Praying Mantis", and other expressive common names. It often arouses curiosity by its peculiar appearance and demeanor. It probably occurs throughout the State, at least east of the mountains, though we have had specimens from only a few localities. It is the only member of the Orthoptera in the State which is known to be predaceous in habit.

Diapheromera femorata. This insect is also known by the name of "Walking-stick", so called because its very slender body gives it a resemblance to small twigs, and because the insect always deliverately *walks*, and never runs or jumps. All through the summer the young insects are greenish in color, corresponding to the color of young twigs and the petioles of

leaves among which they live, but in the autumn when the leaves fall and the twigs become gray or brown, these insects, being then near maturity, turn gray in color. These remarkable resemblances, combined with their deliberate movements, render them quite difficult to detect, unless they force themselves accidentally upon one's notice.

Eritettix navicula. This is one of the true grasshoppers, which so far as has been observed inhabits rather low, grassy grounds. It is an exception in that it is the only species which has the antennael enlarged into a knob or club, at the tip.

Trimerotropis saxitalis. This very remarkable grasshopper is an inhabitant of the exposed, lichen-covered surface of the rocks on some of our mountains. In his trip through the Southeastern States Prof. Morse failed to take it in this State, but recorded its presence on the summit of Stone Mountain, in Northern Georgia. In September last (1906) Mr. Woglum and myself took it quite commonly in favorable spots on the summits of Satula and Whiteside Mountains, near Highlands, Macon County. The species bears a remarkable resemblance to the lichen-covered rocks on which it is found, and when flushed will invariably settle again on the rock, it being only in most exceptional cases that they could be persuaded or forced to alight in grass or herbage. When cornered they would quickly fly back within a foot or two of the collector to again reach the rock, although the species is quite shy when once disturbed.

Leptysma marginicollis. This species is found in grassy places where it clings to the upright stalks or blades, so closely applying its body to the grass as to render detection difficult, both the shape and color of the insect being protective. One remarkable feature of this insect is the fact that the front of the head (or face) slopes away under the body in such degree that the mouth is situated almost between the front legs.

Melanoplus punctulatus. The genus Melanopsus contains many species, the majority of which are not especially striking in appearance or habits, but this species is an exception in that, while all the other species habitually live on the ground or on low-growing grass or herbage, this one is considered to be strictly arboreal, occurring on trees, stumps, shrubbery, etc. Our one specimen of this species was taken in Transylvania County by Mr. Woglum, and is mottled in appearance, which renders its color protective when on lichen-covered bark. It is likely that the species does not occur east of the mountains in this State.

Dissoteiria carolina. This is one of our most common grasshoppers, and in nature (if not in the cabinet) is surely familiar to most observant country people in this State. Among those who have any common name for it, it is known as the Carolina Locust. It occurs throughout the State along roadsides and in cultivated fields. The remarkable thing about this species is the variability of its protective colors. In sections where the soil is grayish in color there the insect is grayish, while only a mile away may be found red clay soil and grasshoppers of a decidedly reddish tinge. Not that the resemblance is perfect, but the difference in color of specimens taken on differently colored soils is quite noticeable. On one occasion in Raleigh I took a specimen on a railway embankment and the greater portion of the body was blackish to correspond to the soot and cinders among which it was found, No similarly colored specimen has since been taken anywhere, and others were not seen at that time.

Gryllotalpa borealis. This is commonly known as the "Mole-cricket", so called from its habit of burrowing in the ground like a mole, and from the further fact that it has developed along very similar lines, the front limbs being much enlarged like the front paws of the mole, and like them are used for digging.

Myrmecophila pergandei. This small and wingless cricket

is found beneath stones in company with ants, whose nests they inhabit, and in cousequence of the darkness prevailing in its usual haunts, is white in color. Thus far it has been taken only at Raleigh, though doubtless it occurs in other localities.

Tridactylus sp. This is a small, blackish species taken at Raleigh early this month for the first time. It was found in low,sandy ground in which it frequently disappeared down very minute burrows. When disturbed or alarmed they jump with marvelous agility, their small size causing them to instantly disappear from view when they once leap away. After capturing several specimens by laboriously approaching them with the killing bottle, we finally began to walk rapidly over the ground and sweep the collecting net back and forth at random, and by this means secured them in considerable numbers.

NOTES ON SOME TURTLES OF THE GENUS PSEUDEMYS.

BY C. S. BRIMLEY.

The genus Pseudemys comprises a number of large fresh water turtles found in the streams and ponds of North America. These have the carapace marked with a more or less variegated pattern of light and dark colors, and are distinguished from allied genera by the broad masticating surfaces of the jaws, which are in the upper jaw divided by a longitudinal ridge parallel to the margin.

The species dealt with in this paper fall more or less naturally into three groups, which are characterized as follows:

GROUP I. Upper jaw with a notch at the symphisis and a cusp or tooth on each side of the notch. Lower jaw, at least, strongly serrated. Ridges in masticating surfaces of jaw tuberculate.

GROUP II. Upper jaw without either notch of cusps, otherwise as under Group I. Plastron always yellow, unblotched.

GROUP III. Upper jaw notched at symphisis, but without cusps. Edges of jaws not serrated. Ridge in masticating surface of jaws not tuberculate.

Group I comprises three nominal species, *P. rubiventris* LeConte, *P. alabamensis* Baur, and *P. texana* Baur. Of these the first and last are certainly distinct species, but the second, of which I have seen no specimens, may be the same as the first.

Of *P. rubiventris* I have seen only one specimen, this be-

ing a live individual from Orlando, Florida, which measured 267 mm. over curve of shell, 245 in straight line, 167 in greatest breadth, 110 in greatest height. Shell strongly arched. Carapace black with red markings, marginal plates with much red below, plastron yellowish brown, but reddish in front and behind, legs with red stripes. The head markings I couldn't see, as he would not put his head out. Lower jaw very strongly serrated, with a serrated cusp at tip; upper jaw slightly serrated, with a median notch and a strong cusp on each side of it. Date, March 16, 1902.

Alabamensis, according to Baur,* has the shell more arched than in *rubiventris*, and the plastron is yellow with brown markings, instead of red as in *rubiventris*.

Of the third species of Group I, *P. texana*, I have seen only two undoubted specimens, one a living specimen from Colmesneil, Texas, measuring 284 over curve of shell, and 265 in straight line; greatest width 215. Shell smooth, not wrinkled, and without traces of a keel. Color slaty brown with yellowish markings, the markings on the costal plates transverse to the longitudinal axis of the shell. Marginals each with a vertical yellow bar down the center. Plastron yellow without markings. Both jaws serrated, the lower much the most so; upper jaw notched in front but without cusps. Date, July 7, 1902.

The second specimen, which was from Shell Bank, La., was much the same color, and had the upper jaw notched in front, with a slight cusp on each side of the notch. Other characters, as in the first specimen. Length in straight line 225, width 150. Date, July 27, 1903.

Group II includes five nominal species, *P. concinna* LeConte, *P. mobiliensis* Holbr,† *P. floridana* LeConte, *P. hieroglyphica*,

* "Notes on the classification and taxonomy of the Testudinata, part IV, The species of the genus Pseudemys" by G. Baur. (Proc. American Philos., Soc. XXXI, May 5, 1893).

† According to Dr. Baur (*loco cito*), *P. mobiliensis* Agassiz is not the same as *P. mobiliensis* Holbr., the former being a composite species equaling *P. alabamensis* Baur plus *P. texana* Baur.

Holbr, and *P. labyrinthica* C. Dumeril, but how many species it really contains I don't know, as individual variation in at least one species seems quite wide and obliterates the distinctive features ascribed to most of the others.

According to Dr. Baur (*loco cito*) these species are characterized as follows:

Concinna by its broad and low shell and its small head.

Hieroglyphica by its elongated, narrow shell and its head, which is still smaller; the yellow stripes and dots on the head are also very much more expressed than in *concinna*.

Labyrinthica shows the coloration of head and neck of *hieroglyphica*, but the head is larger and the shell more as in *mobiliensis*, but by far not so large.

Mobiliensis has the head like *concinna*, but larger, the shell very much more arched especially in front, the animal much larger than in *concinna*, the upper shell reaching a length of 385 over the curve.

Floridanus is at once distinguished by its oval form and the great elevation of the carapace and its color. The carapace has a very dark brown color with numerous irregular lines of yellow. The marginals are dark brown and have only one vertical, median yellow line, and are without the yellow concentric lines so characteristic of *concinna* and *mobiliensis*. The carapace is much more arched than in *mobiliensis* and nearly forms a half circle. The skull is also larger than in this species and the jaws are not serrated (*sic*).

The characters quoted above, except those for *floridanus*, all fall within the range of individual variation of Raleigh specimens of *concinna*, and hence until I am able to examine specimens of the others, I cannot help feeling doubtful of their validity.

Raleigh specimens of *concinna* present the following characteristics: The carapace is marked with a variegated pattern

of brown and yellow lines, these forming more or less distinct concentric figures, parts of three of which usually enter each costal plate. Markings of the carapace usually not definitely transverse to the axis of the body, on the costals. Marginal plates marked above with a median, vertical, yellow bar, and yellow concentric figures between the yellow bars of adjoining plates; quite frequently, however, the vertical bars are absent on some of the plates and the concentric figures replaced by longitudinal yellow lines, continuous on adjoining plates, this occurring on the middle and posterior marginals, but not usually on the anterior ones. In seven adults this feature is present or absent as follows: In one the longitudinal lines replace the vertical bars and concentric lines on all the marginals; in two others they do not occur at all; in a fourth they occur only on marginals 4, 5, 6, right, and 11, 12, left; a fifth has them on the four middle marginals on each side; a sixth on numbers 5, 9, 7, right, and 6, 7, left; a seventh, on numbers 4, 7, 8, 9, 11, on both sides, and on No. 12, right also. The presence of a vertical yellow bar across the center of each marginal is so constant in all specimens of *Pseudemys* that I have seen, except those from Raleigh, that the variation seems worth noting. Head and legs with yellow stripes. Plastron yellow, unblotched.

In the shape of the shell there is also a good deal of variation, some specimens being broad and flat with a median, dorsal depression; others are broad and flat but lack the dorsal furrow, while others again have comparatively high and arched shells, and in any case the dorsal depression is only present in full grown specimens, not in young nor in half grown ones. The flat shelled specimens seem to be mainly males, and the more arched ones females, but I have not examined enough specimens to be sure that the variation is wholly sexual and not individual.

The size of the head also varies, being large in some specimens and small in others, the difference being apparently

sexual, the small headed ones being males,* the large headed ones females. Young specimens are nearly circular with a distinct dorsal keel, as in all young *Pseudemys*, but a specimen 130 mm. long has substantially the form of the adult.

Some measurements of specimens from Neuse River near Raleigh are as follows:

	Taken.	Greatest Length.	Width.	Height.
1.	Feb. 26, 1902, sex?	131	107	55
2.	April 23, 1906, male	150	114	54
3.	March 29, 1904, female	161	—	—
4.	July 27, 1903, sex?	202	139	—
5.	March 24, 1903, male	211	150	82
6.	March 29, 1904, female	240	158	—
7.	June 2, 1905, sex?	240	172	80
8.	March 24, 1903, female	275	185	110
9.	March 16, 1902, sex?	280	195	107

Of what Baur called *mobiliensis*, I have had one adult and several smaller specimens from Baker County, in Southwest Georgia, but while the adult has an arched shell and is a little larger (290 mm. long) than the largest I have measured from Raleigh, its shell is not more arched than those of some Raleign specimens, nor is the head larger than in some of them. In coloration it is identical with Raleigh specimens, as are also the young ones, except that none of them have any vertical yellow bars and concentrix markings on the marginals replaced by longitudinal yellow lines. I am inclined to consider this form as merely, at the most, a large southern form of *concinna*.

Of *floridana* I have had three good sized adults from Johnston County, N. C., and quite a number of small and half grown specimens from Southwestern Georgia, and Florida. These differ from *concinna* in usually having a vertical yellow

* See also "Some observations on the turtles of the genus Malademmys" by O. H. Hay, (Proc. U. S. N. M., Vol. XV, No. 908) in which he states that the females of this genus have larger heads than the males.

bar, forking at the upper end, down the center of the first and second costal plates, and in having the markings on the rest of the shell less concentric and usually in larger pattern. The marginal plates have a vertical yellow bar down the center of each, with concentric markings between; these latter, however, only occur in quite small specimens, as they disappear early in life leaving only the vertical bar. Head, legs, and plastron colored as in *concinna*. Ground color of carapace dark brown, darker than in *concinna*. The really important difference lies, however, in the shape of the shell, which is shorter and more arched than in *concinna*, being in fact more nearly the shape of that of *P. scripta*, to which species *floridana* bears a superficial resemblance. The males have smaller heads and lower shells than the females.* The upper jaw is slightly, the lower jaw strongly, serrated, in all specimens that I have seen.

The measurements of the shells of some specimens are:

	Taken.	From.	Length.	Width.	Height.
1.	June 20, 1905,	Johnston Co., N. C.,	250	197	110
2.	June 30, 1905,	" " "	222	149	95
3.	June 30, 1905,	" " "	169	—	—
4.	May 14, 1904,	Baker Co., Ga.,	136	114	57
5.	July 20, 1904,	" "	150	—	—

I have seen no specimens of *labyrinthica* or *hieroglyphica* and the characters assigned to them by Dr. Baur (*loco cito*), are not of specific value, as they fall within the range of the individual variation of *concinna*. As *labyrinthica* is smaller than *concinna* and *mobiliensis* larger, it is quite possible it is a smaller† northern race of that species, just as *mobiliensis* appears to be a larger southern race.

* According to Dr. Baur (*loco cito*) *floridana* does not have serrated jaws, qut he places it in a section of the genus with lower jaw strongly serrated, so the absence of serrations probably applies only to the upper jaw, where they are little evident.

† *Labyrinthica* occurs in Tennessee and Illinois in the tributaries of the Mississippi.

Group III comprises three species which agree in having the upper jaw with a notch at the symphisis, but without cusps on each side of the notch, in the edges of both jaws being without serrations, in the ridge in the masticating surface of the jaws being non-tuberculate, and in the plastron being more or less blotched. These three are *scripta* of the Southeastern United States, and *elegans* and *troostii* of the Mississippi Valley and southwestward.

The three may be distinguished as follows:

1. Carapace keeled at all ages, a vertical yellow bar just behind eye. *Scripta.*

   Carapace not keeled in adult, no vertical yellow bar behind eye.

2. An elongate-oval red mark on neck behind eye. *Elegans.*

   No oval red mark on neck. *Troostii.*

Scripta is a large, heavily-built terrapin, with a wrinkled shell, and a distinct dorsal keel at all ages. A diagnostic mark of this species is a vertical yellow figure just behind the eye. The marginals are marked as usual in the genus with a vertical yellow bar and concentric figures between; the latter, however, are usually absent in adults. The carapace is marked on the costals with yellow, black and brown markings, there being usually a central yellow stripe down the middle of each costal with yellow and brown lines parallel to it and meeting their fellows above its upper end, and to some extent below its lower end; the black is more irregular in amount and position than the other colors, but there is always some black on each plate in the adult, although it is wanting in young specimens. On the posterior costals the markings are less regular and more confused. The plastron is yellow, or occasionally brownish, with a round black spot on each of the two anterior plates; often there is a black spot on the next two plates also, and occasionally one on every plate,

The largest specimen I have seen weighed seven and a half pounds and measured 272 mm.

Elegans is much like *scripta* in general appearance and in markings, but the shell is flatter and not keeled in the adult and the red neck spot is characteristic at all ages. The markings on the carapace are variable, but usually much as in *scripta*, but those of the plastron are different, each plate usually containing a black or dusky spot which is usually surrounded by one or more dusky concentric lines.

Of *troostii* I have only seen one specimen and that differed greatly in many respects from all the specimens of *scripta* and *elegans* that I have seen. It was from St. Louis, Mo., and measured 185 in length and 137 in breadth, and the tip of the nose extended 107 mm. beyond the front edge of the shell, when the neck was stretched to its fullest extent. The upper jaw was notched in front, lower jaw pointed at tip, neither serrated. Both upper and lower jaws much wider and more rounded than in any other *pseudemys* with which I am acquainted, especially than in *elegans* and *scripta*, which have the snout notably pointed. Head dark above with narrow, pale stripes; chin, throat, and neck below, light colored with rather pale darker stripes on neck below, much as in *Deirochelys reticulata.* Shell rather flat on top, rounded off on sides, rather deep, and much the shape of *Deirochelys*, but the bridge and shell not so high; shell smoother and without the wrinkles so characteristic of *Deirochelys.* Carapace dark brown with indistinct paler markings, most of the marginals with faint vertical bars which are barely visible. Plastron pale with some dark markings round the edges of the plates. Superficially and in length of neck this specimen resembles a *D. reticulata* more than it does the other species of *Pseudemys*, but I found on examination that the basal portion of the ribs was short, straight and broad as in other *Pseudemys*, not long, slender and arched as in *Deirochelys.*

SPECIMENS EXAMINED.

P. rubiventris, Orlando, Florida, one.

P. texana, Colmesneil, Texas, one; Shell Bank, La., one.

P. concinna, Raleigh, N. C., nine adults and several young.

P. mobiliensis (=*P. concinna*?), Mimsville, Ga., one adult, two young.

P. floridana, Johnson County, N. C., three adults; Orange County, Fla., two young; Mimsville, Ga., two half-grown specimens and several young.

P. scripta, numerous specimens from Raleigh, N. C., and Mimsville, Ga.; Lake Ellis, N. C., several.

P. elegans, Austin, Texas, three; St. Louis, Mo., three; Shell Bank, La., one.

P. troostii, St. Louis, Mo., one

THREE LITTLE KNOWN SPECIES OF NORTH CAROLINA FUNGI.

BY J. G. HALL.

It is my purpose to take up three species of fungi that are little known in North Carolina, and in fact in the United States, and to give a brief description of them.

The first two belong to the Hyphomycetes of Saccardo, but to different groups under this head. The third belongs to the Pyrenomycetes, and the family Sphaeriaceae.

The first I have preferred to call by the known name of Martensella pectinata, although as will be seen later, there are sufficient differences to make it a new species. It was first described by Coemaus in 1863 from Belgium.

This fungus is new to North Carolina, and in so far as I have been able to determine, has not been reported in print from the United States, although I know it to be in culture in one other place than West Raleigh.

The discovery of this species was partly an accident. Last December I was making some plate cultures from some soil that came from New Bern, in the eastern part of the State, for Sclerotinia, a lettuce disease upon which we have conducted a series of experiments.

In the culture I noticed growing a fungus that at first I took to be Botrytis, but upon microscopic examination found to be Martensella.

The fruiting hyphae stood erect and unbranched, except for the short spore bearing stalks, although later I found that the fungus became branched, and some times very much so.

The erect hyphae are septate and after arising a short distance above the substratum each cell sends out a short branch near the outer end. These short branches become the sporophores, and at first are indistinguishable from the main hypha except in size. Almost immediately the tips of the sporophores bend upward at approximately right angles and the portion beyond the bend rapidly becomes closely septate, having six to nine septae. The sporophores very soon become boat-shaped with the keel toward the main hypha. Upon the side away from the main hypha there arise small protuberances, the first appearing nearest the bend, and then being produced in succession toward the tip.

These growths early begin to show a slight swelling, forming a kind of head at the tip, which later lengthens into the fusiform spores; these are constricted into a very fine thread at the base, which connects them with a swollen base (basidia) that joins them to the naviculate sporophore.

Saccardo places this fungus in that group of the Hyphomycetes called the Mucedineae, because of the looseness and lightness of color of the mycelium. Also among the Amerosporeae of the latter, because of the shape and color of the spores.

In quoting the original description in his Sylloge Fungorum Saccardo says that the sterile hyphae are procumbent, with the fertile erect, with both branched and septate; the spores are borne on short lateral branches and in two rows along the face of the naviculate sporophore, being cylindric-fusiform in shape, and measuring 10-20x3 μ; that it is parasitic on Muco and the Saprolegneae. After giving the habitat a note is added saying that Cremans describes some of the spores as being borne in chains, and Engler & Prantl reproduce figures of the fungus which show some of the sporophores bearing catenulate spores, which are nearly globose in shape.

After the note Saccardo makes the very significant remark that the appearance of the catenulate spores is exceedingly strange.

Engler & Prantl also show the sporophores with the spore-bearing surface upward and inward.

In the early part of this note I said that I believed I would be justified in making a new species on account of the differences I found between my specimens and those in Saccardo and Engler & Prantl. I found: that the plant grew very freely with Penicillium as a host; that the spores are never borne in chains but always singly; that instead of being borne in two rows along the face of the sporophore, they are arranged all over its surface. In other respects my specimens agree with the descriptions noted.

The second species that we consider is one of the Genus Epicoccum, which belongs to the Tuberculariae, another group of the Hyphomycetes, so called because the mycelium forms a tubercle or mass of threads from which the spores arise.

The spores are borne in masses almost without sporophores, but what there is of them is light brown, although the greater part of the Mycelium is white. The spores are black when mature but brownish black in the younger stages. They are rough on the surface and look very much as if they were four-celled, but I have not been able to see any definite partitions. They are globose and measure from twenty to thirty μ in diameter.

In germination the spores send out short, almost globose cells, and after forming two or three of these at each point of germination, they grow into the regular septate hyphae, which continue to lengthen for some time.

Near the growing tip of the mycelium short branches arise, at first just a single filament, but very soon becoming much and irregularly branched, forming a hemispherical mass (sporodochium) upon the surface of which the spores are borne.

As an experiment this fungus was grown upon several different kinds of media to see if different nutrients had different effects upon it.

A medium which we called C. B. A., Chemical Base Agar, was made as follows: Water, 1000 grams; Di Potassium-phosphate, 2.5 grams; Calcium Chloride, 01 gram; Magnesium sulphate, 01 gram; Sodium Chloride, 2.5 gram; Potassium sulphate, 2 grams; Agar, 15 grams.

To this was added Sodium Asspariginate in one case; Sodium Asspariginate and Starch in another; Sodium Asparriginate and glucose in another, and one or two others. Four per cent. Pea Agar and Apple-twig Agar were also used.

On the Pea Agar the Mycelium was white with very few pink spots; upon the Apple and Apple-twig Agar the Mycelium was orange yellow with abundance of pink spots. Upon C. B. A. and N. A. S. and N. A. G. the Mycelium was white but with a large number of large pink spots. In all cases spores were formed in equal abundance and they were most numerous near the point of inoculation.

The third and last species belongs to a very different group of fungi, the Pyrenomycetes, which has its spores borne in sacs (asci) within closed or nearly closed conceptacles called perithecia. In giving the systematic position of this species, I shall follow Ellis & Everhart's North American Pyrenomycetes.

This is a new species of fungus, but I hesitate to give it a name because of the scarcity of material. It is one of the Genus Podospora, in the family Sordaieae, which is one of the sub-order Sphaerioceae.

The perithecia are borne singly and scattered, are black and flask-shaped. The asci are clavate and bear the eight spores which are the distinguishing feature of the plant. They are dark, elliptical, and are joined by a filament into pairs.

So far as I have been able to learn, there is only one species that approaches this in any way, and that is Podospora zygospora, in which the spores are similarly joined in pairs, but the thread joining each pair is septate, while in this one there are no septae in the connecting thread.

JOURNAL

OF THE

Elisha Mitchell Scientific Society

NOVEMBER, 1907

VOL. XXIII NO. 3

PROCEEDINGS OF THE ELISHA MITCHELL SCIENTIFIC SOCIETY, JANUARY 1907 TO OCTOBER 1907.

169TH MEETING, JANUARY 15, 1907.

H. V. Wilson: The Regenerative Power of Sponges.
J. W. Gore: Direct Current Transmission of Power.
The Electrical Aging of Flour.

170TH MEETING, FEBRUARY 12, 1907.

J. H. Pratt: The Fish and Oyster Industries in North Carolina.
Collier Cobb: Some Húman Habitations.

171ST MEETING, MARCH 19, 1907.

J. E. Latta: Some Recent Developments in Electric Traction.
N. C. Curtis: Architectural Composition.

172ND MEETING, APRIL 16, 1907.

Archibald Henderson: The Foundations of Geometry.
Chas. H. Herty: The Optical Rotation of Turpentines.

At the close of the program a business meeting was held to consider the programs. It was voted that a minimum of four meetings be held each year but, if possible, one meeting per month.

BUSINESS MEETING, SEPTEMBER 23, 1907.

A business meeting was held in the chemical laboratory with Pres. Herty in the chair. The following officers were elected for the ensuing year:

President: W. C. Coker.
Vice-President: J. E. Latta.
Permanent Secretary: F. P. Venable.
Recording Secretary: A. S. Wheeler.
Editorial Committee:

W. C. Coker, Chairman.
A. Henderson.
E. V. Howell.

A. S. WHEELER, Recording Secretary.

A NEW METHOD BY WHICH SPONGES MAY BE ARTIFICIALLY REARED.[1]

DR. H. V. WILSON

I have found in the course of an investigation carried on for the Bureau of Fisheries that silicious sponges when kept in confinement under proper conditions degenerate, giving rise to small masses of undifferentiated tissue which in their turn are able to grow and differentiate into perfect sponges. The investigation has been prosecuted during the past three summers at the Beaufort Laboratory. While the degeneration with the formation of the indifferent masses has been observed in several species, it is only in one species, a *Stylotella*, that the process as a whole has been worked out.

This sponge, which is exceedingly abundant in Beaufort Harbor, is a fleshy monactinellid commonly reaching a thickness and height of 10–12 cm. Conical processes with terminal oscula project upwards from the lower body. With this species, which is a light-loving form, I have obtained the best results when outside aquaria, either concrete aquaria or tubs, were used. The method of treatment is briefly this: Into a tub about 60 cm. by 30 cm. and covered with glass, a half dozen sponges, freed as far as possible from live oysters and crabs, are put. They are raised from the bottom on bricks. The tub is emptied, filled and flushed for some minutes three times in every twenty-four hours. Direct rays of the

1Published with the permission of Hon. Geo. M. Bowers, U. S. Commisioner of Fisheries.

Reprinted from SCIENCE, N. S., Vol. XXV., No. 649, Pages 912-915, June 7, 1907,

sun should be avoided. Tubs answer as well as concrete aquaria, and have the advantage of being movable.

In a day or two the oscula of the sponge disappear, and the surface begins to acquire a peculiar smooth, dense and uniform appearance. Microscopic study reveals the fact that not only the oscula, but the pores also, for the most part close, and the canal system becomes interrupted and in some degree suppressed. The mesenchyme is more uniform, and is denser than in the normal sponge, owing in part at least to the disappearance of the extensive collenchymatous (very watery mesenchyme) tracts of the latter.

The whole sponge may pass into this state and remain without great change for weeks. During this period it shrinks greatly in size, in a given case to one quarter the original bulk. The arrangement of the skeletal spicules becomes much simplified. With the shrinkage in size the sponge becomes more solid, *i. e.*, more of the canal space is suppressed. Some flagellated chambers persist and there are a few small scattered apertures on the surface. The bulk of the chambers disappear as such, the collar-cells transforming into simple polyhedral masses which become scattered singly or in groups in the general mesenchyme. The mesenchyme is a syncytium composed of well-marked cells that are freely interconnected. The sponge in this condition closely resembles *Spongilla* in its winter phase, as described by Weltner.[2] Presumably water continues to circulate through the body, but the current must be an exceedingly feeble and irregular one.

As a sponge in this condition continues to shrink, it may subdivide and thus a large sponge may eventually be represented by numerous masses, in a given case about 1 cm. in diameter. Now if the sponge in this condition or if one of the masses into which it has split up, be attached to wire gauze and suspended in a live box floating at the surface of the open water of the harbor, the sponge or piece will in a few days grow and redevelop the pores and oscula, flagellated chambers, tissue differentiation, and skeletal arrangement of

2 'Spongillidenstudien, II. Archiv fur Naturgeschichte,' 1893.

the normal sponge. Whether in this regeneration the transformed and separated collar cells again unite to form the flagellated chambers, I can not say. I think it very doubtful.

In the two classes of cases just described the sponge as a whole degenerates and slowly shrinks. Cellular death takes place so gradually that at no time is there any obvious corpse tissue or skeletal debris. Much more common and of far greater interest are the following cases. In these a large part of the sponge body dies in the course of two or three weeks, leaving the skeletal network still in place and bearing the brown decaying remnants of the flesh, which, as maceration continues, are washed away. In places, however, the sponge body does not die. Here masses of living tissue are left, conspicuous amidst the dead remains by their bright color and smooth clean surface. These living fragments may be classified into three groups. First, the upper end of an ascending lobe or a considerable part of the body of the lobe may be left alive in its entirety, thus forming a more or less cylindrical mass up to 5 mm. diameter, with a length sometimes two or three times the thickness. The histological condition of these masses is not very different from that of the sponges already described. Such a mass may be said to consist of anastomosing trabeculæ, separated by the remains of the canal system. The mesenchyme composing the trabeculæ consists of discrete cells interconnected by processes to form a syncytium. The flagellated chambers as such have nearly disappeared, although remnants may still be recognized. In them the collar cells have transformed into simple polyhedral bodies that are widely separated. The bulk of the chambers have broken up into their constituent cells, and these are now scattered as elementary parts of the general mesenchyme. When such masses are attached to wire gauze and hung in a floating live-box they transform into perfect sponges.

A second class of surviving remnants includes masses scattered over the general surface of the sponge. These may be spheroidal and small, less than one millimeter in diameter. Usually they are flattened and of an irregular shape with

lobes, suggesting a lobose rhizopod or myxomycete plasmodium. Such masses which may be connected by slender strands are commonly from two to five millimeters in the longest direction. The third class of remnants are found scattered through the body of the dead and macerated sponge, in which they sometimes occupy positions that are obviously favorable for respiration. These bodies are more or less spheroidal and small, their diameter varying commonly from one half to one and a half millimeters. In the most successful cases of treatment, the small masses, internal and superficial, are exceedingly abundant, and the dead and macerated sponge body with its contained nodules of conspicuous living tissue strongly suggests a *Spongilla* full of gemmules.

These living remnants of the sponge (bodies of the second and third classes) execute slow amœboid changes of shape and position, behaving thus like plasmodia, and they may be designated as plasmodial masses. Microscopic examination shows them to be of an exceedingly simple character. without canal spaces or flagellated chambers. The mass does not consist of discrete cells, but is an aggregation of syncytial protoplasm studded with nuclei. The protoplasm is stored with minute inclusions and is reticulate in arrangement. The nuclei are practically all alike, and there are no signs of persisting collar-cells. Such a mass represents a portion of the original sponge in which the degenerative changes have progressed farther than in the larger remnants. In the latter we find a syncytium made up of discrete cells among which some persisting collar-cells are distinguishable. But in the plasmodial mass the cells have united so intimately that cell outlines have been wiped out, and recognizable collar-cells (or their nuclei) have disappeared. The optical evidence points to the conclusion that the latter help to form the general syncytium, undergoing regressive changes in their differentiation which result in their becoming indifferent parts of this unspecialized tissue.

The plasmodial masses remain alive in the laboratory indefinitely, but do not transform. They attach to the bottom

of the vessel, but so feebly as to be easily shaken loose. In order to see if they would transform when returned to natural conditions, I devised the simple plan of enclosing them in fine bolting-cloth bags which were hung in a live-box floating in the harbor. The bags, rectangular, were divided into compartments about an inch square with the two flat sides nearly touching. In each space an isolated plasmodial mass was inserted, and the bag sewed up. It was found that in such bags the masses were held in place long enough for them firmly to attach to the bolting cloth. Once attached to the cloth they grow, sometimes quite through the wall of the bag to the outer water, and transform into perfect sponges with osculum, canals, pores and flagellated chambers in such abundance as to be crowded.

This ability to undergo—when the environment is unfavorable but not excessively so, regressive changes of differentiation resulting in the production of a simpler, more uniform tissue, is something that is plainly useful, *i. e.*, adaptive. In the simplified state the sponge protoplasm withstands conditions fatal to such parts of the body as do not succeed in passing into this state, and on the return of normal conditions again develops the characteristic structure and habits of the species. That this power is exercised in nature there can scarcely be a doubt, since the conditions that are present in an aquarium must now and then occur in tidepools.

It is probable that the power thus to degenerate with the production of masses of regenerative tissue is general among sponges. I first discovered the phenomenon in *Microciona*, a very different form from *Stylotella* and one in which the skeleton includes much horny matter. And in two other Beaufort species I have succeeded in producing the plasmodial masses. There is every reason for believing that the commercial sponge shares in this ability. If this is so, we have here a means of propagation which with a further development of methods may at some time become economically practicable. In any case it is now possible to study the differentiation of a quite unspecialized tissue, one that is physi-

ologically embryonic, into a perfect sponge at any time of the year irrespective of the breeding season. We may even exercise some direct control over the size of the plasmodial masses, as the following experiment shows.

Microciona was kept in aquaria until the degenerative process had begun. Pieces were then teased with needles in a watch glass of sea water in such a way as to liberate quantities of cells and small irregular cell-agglomerates. These were gently forced with pipette to the center of the watch glass. Fusion of cells and masses, with amœboid phenomena, began at once, and in half an hour quite large irregular masses existed. In the course of a few hours the masses grew enormously through continued fusion. From this time on they adhered firmly to the glass, retaining irregular plasmodium-like shapes, and the growth was inconspicuous. To bring them together once more and induce further fusion they were on the following day forcibly freed, with pipette and needle, and to clean them of cellular débris and bacteria were transferred to a tumbler (covering with bolting cloth) in which they were kept actively moving under a fine glass faucet for about thirty minutes. In the course of this violent agitation a good many masses were lost. Those remaining in the tumbler became in the next few hours noticeably rounder and smoother at the surface. From this experiment eighteen more or less spheroidal masses were obtained, some of which measured one half millimeter in diameter. They were similar to the small plasmodial masses produced in this species (and in *Stolotella*) when the sponges are allowed to remain quietly in aquaria. As already stated, it is only in *Stylotella* that I have directly proved the regenerative power of these masses.

Maas has just announced[3] that calcareous sponges (*Sycons*) when exposed to sea water deprived of its calcium undergo

3 'Ueber die Einwirkung karbonatfreier und kalkfreier Salzlösungen auf erwachsene Kalkschwämme und auf Entwicklungsstadien derselben. Archiv fur Entwicklungsmechanik der Organismen,' Bd. XXII., Heft 4, December, 1906.

marked degenerative changes, which may be of such a character that the living tissue quite separates from the skeleton and breaks up into compact cords of cells showing active amœboid phenomena. The cords further constrict into rounded masses the likeness of which to gemmules is pointed out. Maas states that he is not yet in a position to say whether these masses have the power to transform into sponges, but adds that some of his observations induce him to believe that this is possible.

It is evident that Maas, working on very different forms, has independently met with the same degenerative-regenerative phenomena as are described in this communication, the essential facts of which were presented (together with an exhibit of gemmule-like degeneration masses and young sponges into which such masses had transformed) at the recent December meeting of the American Society of Zoologists. I may add that more than two years ago at the end of the summer of 1904, in my official report (unpublished since the research was still in progress) to the Bureau of Fisheries on the investigation under my charge, I described the degenerative phenomena in *Microciona* and *Stylotella*, *i. e.*, the formation under certain conditions of confinement of minute masses presenting a likeness to gemules, and emphasized the probability that these masses were able to regenerate the sponge. It was not, however, until the summer of 1906 that I was able to demonstrate the truth of this view.

UNIVERSITY OF NORTH CAROLINA.
CHAPEL HILL, N. C.,
February 16, 1907.

THE CONDENSATION OF CHLORAL WITH PRIMARY AROMATIC AMINES. II.*

BY ALVIN S. WHEELER.

A number of condensation products of chloral with primary aromatic amines have already been described. The first mention of such a reaction is probably that of Maumené[1] who hoped to obtain indigotine by the action of chloral (2 mols.) upon aniline (3 mols.). His product was a brownish black uncrystallizable substance containing no chlorine. Schiff and Amato[2] first describe a condensation product of chloral (1 mol.) and aniline (2 mols.) with the formula

$$CCl_3CH(NHC_6H_5)_2.$$

In the same year Wallach[3] describes this compound. Later[4] he gives a full description of the products obtained from aniline, p-toluidine, and a sample of xylidine boiling at 212°-216°. Eibner[5] studied the condensation of chloral with p-nitraniline, m-chloraniline, p-chloraniline, and 1, 2, 4-dichloraniline and showed that 1, 2, 4, 6-trichloraniline and 2, 6-di-

*Contribution from the Chemical Laboratory of the University of North Carolina.

1[Ber. 3. 246, (1870)].

2[Gazz. chim. ital. 1,376 (1871)].

3(Ber. 4. 668).

4(Ann. 173,274).

5(Ann. 302,235).

chlor-4-nitraniline do not react. Wheeler and Weller[6] prepared the o- and m-nitraniline compounds and Wheeler and Daniels[7] showed that only addition products could be obtained with the naphthylamines. Niementowski and Orzechowski[8] found that one molecule of chloral condensed with one molecule of anthranilic acid but later[9] obtained the expected diphenamine compound. Finally Rügheimer[10] describes the compounds with o- and p-phenylenediamine and 1, 2, 4- and 1, 3, 4-toluylenediamine. He also states that only addition products are obtained with the naphthylamines.

The chloral diphenamine compounds vary considerably in stability. Most of them may be kept for years. They possess great crystallizing power. Their behavior toward alkalies is variable. The aniline derivative is decomposed by alcoholic potash into aniline, chloroform and phenyl cyanide according to Wallach. The p-nitraniline derivative is converted by alcoholic potash into an hydroxy compound, one chlorine being replaced by the hydroxyl group according to Wheeler and Glenn[1]. They are not stable in the presence of strong mineral acids. These split the compound so as to reform the amine. Eibner has shown that boiling acetic anhydride and benzoyl chloride give the acetyl or benzoyl derivative of the original amine. I have found that all of them react with great readiness with bromine in the cold. There is a substitution of one hydrogen atom in those which have been analyzed. This substitution probably occurs in the methylene group of the chloral residue.

With the exception of the anathranilic acid products the following are thought to be new.

6(Jr. Am. Chem. Soc. 24, 1063).

7[Jr. Elisha Mitchell Sci. Soc. 22, 90 (1906).

8(Ber. 28, 2812).

9(Ber. 35, 3898).

10(Ber. 39, 1653).

1(Jr. Elisha Mitchell Sci. Soc. 19, 63, 1903).

CHLORAL AND p-BROMANILINE.

Trichlorethylidenedi-p-bromphenamine,

$$CCl_3CH(NHBrC_6H_4)_2.$$

With C. W. Miller. Ten grams of p-bromaniline were dissolved in 50cc benzene and 8 grams of chloral (4.2 grams required by theory) in 10cc benzene were added. The mixture was concentrated one-half on the water bath and cooled. A white flocculent precipitate came down. This gave a melting point of 135°. On further evaporation a second crop was obtained, showing a melting point of 119°. By several recrystallizations from benzene the melting point was raised to 140°. The yield of the crude product was quantitative.

Analysis:

0.1588g substance gave 0.2049g CO_2 and 0.0352g H_2O.
0.1638g substance gave 9cc nitrogen at 15° and 755mm.
0.0890 substance heated with 0.3274g $AgNO_3$ required 9.8cc NH_4SCN (1cc = 0.0173g $AgNO_3$).

	Calculated for $C_{14}H_{11}N_2Cl_3Br_2$	Found
Carbon	35.45	35.03
Hydrogen	2.34	2.46
Nitrogen	5.93	6.38
Chlorine + bromine	56.24	55.58

Trichlorethylidenedi-p-bromphenamine consists of fine colorless needles, melting at 140° and decomposing at 205°. It is extremely soluble in alcohol, acetone, glacial acetic acid and hot benzene. It is sparingly soluble in cold benzene and insoluble in ligroin. It is readily purified by using a mixture of benzene and ligroin. It is not decomposed by boiling water but is split by boiling concentrated hydrochloric acid with the regeneration of p-bromaniline. A bromo derivative is easily obtained by adding bromine to a glacial acetic acid solution. The product, consisting of plates, melts at 203°

after several recrystallizations from glacial acetic acid. Determinations of carbon, hydrogen and nitrogen give very satisfactory figures for a monobrom compound. A study of its constitution is under way. Chlorine gives a similar reaction. The product, crystallizing in long colorless needles, melts at 93° after recrystallization from glacial acetic acid. Analysis indicates a monochlor derivative. These bodies will be described in a later paper.

CHLORAL AND O-ANISIDINE.

Trichlorethylidenedi-o-methoxyphenamine,

$$CCl_3CH(NHOCH_3C_6H_4)_2.$$

With W. S. Dickson. Two molecules (12.3g) of o-anisidine were dissolved in 50cc benzene and one molecule (7.3g) of chloral were added. After warming a short time on the steam bath a separation of colorless needles occurred. These decomposed at about 215° and weighed 0.05g. On concentration of the filtrate in a dessicator a mass of fern-like crystals was obtained mixed with a thick liquid. After filtering the crystals were pressed on a porous tile. The product was white, melted at 112°-114° and weighed 9.7 grams. On recrystallizing from benzene the melting point was raised to 121°. The thick liquid finally solidified, considerably increasing the yield.

Analysis:

0.2000 gram substance gave 0.2294 gram AgCl.

1.0000 gram substance gave 0.073 gram nitrogen (Kjeldahl).

	Calculated for $C_{16}H_{17}O_2N_2Cl_3$	Found
Cl	28.35	28.35
N	7.47	7.30

Trichlorethylidenedi-o-methoxyphenamine crystallizes from ligroin or benzene in magnificent rhombohedra, from one

quarter to one half inch long, always with a slight yellow color. It is easily soluble in cold benzene and carbon tetrachloride and hot glacial acetic acid. It is slightly soluble in cold ligroin and fairly soluble in hot ligroin. It crystallizes from alcohol in long slender prisms. One hundred cubic centimeters of boiling alcohol will dissolve approximately 7 grams and at 25° about 2.5 grams. It is insoluble in and unchanged by boiling water. When boiled in concentrated hydrochloric acid the odor of chloral could be detected in the vapors. A bromo derivative is readily obtained by adding bromine to a concentrated glacial acetic acid solution. The crystals occur in clusters of needles and decompose at about 230°. This compound is being further investigated.

CHLORAL AND p-ANISIDINE.

Trichlorethylidenedi-p-methoxyphenamine,

$$CCl_3CH(NHOCH_3C_6H_4)_2.$$

To a solution of 12.3 grams p-anisidine in 20cc benzene (a nearly saturated solution) is added 7.3 grams chloral. The solution turns to a dark red color at once, much heat is developed and a deposition of 0.22 gram small colorless crystals occurs. These decompose at about 215° as in the case with o-anisidine. After filtering, the reaction mixture is boiled 15 minutes and then allowed to stand several hours. An abundant crystalline precipitate is formed. After filtering and pressing on a clay plate, the product melted at 115° and weighed 10.5 grams. A further yield was obtained from the mother liquor. Purification was effected by using the mixed solvent, benzene and ligroin. The melting point was raised to 118°-120°.

Analysis:

0.2087 gram substance gave 0.2398 gram AgCl.

	Calculated for $C_{16}H_{17}O_2N_2Cl_3$	Found
Cl	25.35	28.41

The para compound crystallizes from ligroin in brilliant scales, showing a strong pink color in the mass. It melts at 118°-120° and decomposes at 158°. It is fairly soluble in cold benzene, alcohol and ether. It is readily soluble in glacial acetic acid, hot benzene and hot alcohol. The hot alcohol solution emits a most disagreeable odor and on spontaneous evaporation to dryness a jet black crystalline mass remains. It is very slightly soluble in cold ligroin and not readily in hot ligroin. On treatment with bromine in glacial acetic acid solution a crystalline product is obtained which blackens at about 198°. This compound will be studied further.

CHLORAL AND ANTHRANILIC ACID.

The product obtained in this case depends upon the proportions used. One molecule of chloral will condense with one or two molecules of anthranilic acid with the elimination of one molecule of water. The two products have been described by Niementowski but his method yields a mixture and we have improved upon it since we wish to make the compounds in quantity in order to study their bromo derivatives.

Trichlorethylidene-o-aminobenzoic Acid,

$$CCl_3CHNC_6H_4COOH.$$

With W. S. Dickson. Five grams of anthranilic acid were dissolved in 40cc boiling benzene (a saturated solution) and 5.5 grams chloral in 10cc benzene were added. The weights are in the proportion of one molecule to one molecule. The mixture was boiled under a reflux condenser for three hours, filtered from a small precipitate and then cooled. A crystalline deposit, weighing 5.0 grams and melting at 148°-151°, separated. The crystals were large elongated tables, occurring in clusters. From the filtrate was obtained 3.0 grams of material, melting at 145°-150°. Several recrystallizations from benzene raised the melting point to 152°. Niementow-

ski and Orzechowski[1] prepare this compound without the use of any solvent. They use an excess of chloral and get several by-products. We have tried their method but have employed theoretical proportions. Even so we get the same by-products. We set the mortar in a block of ice and rapidly stirred together the previously cooled substances. The mixture liquefied and then rapidly became very hard. This product decomposed at about 127°, after two hours on ice at 124° and after three hours more at room temperature at 118°. It was rubbed up with a little water and filtered. The decomposition point rose to 135°. Now taking advantage of the marked difference in solubility in benzene of the mono- and di-compounds (not observed by Niementowski) we extracted the crystalline mass, weighing 8.2 grams, with 45cc boiling benzene. From the extract there separated a mass of colorless needles, weighing 3.7 grams and melting 149°-152°, hence nearly pure mono-compound. On evaporating the filtrate a residue was obtained, weighing 1.3 grams and melting at 160°, a good quality of the di-compound. A second extraction was made with 33cc of boiling benzene. On cooling this yielded a product weighing 0.8 gram and melting at 162°, and a residue at 157°. There still remained an insoluble residue, dark purple in color. These results are in marked contrast to those obtained by our method of boiling in benzene, for we get practically only the mono-compound and consequently a much larger yield.

Analysis:

0.2000 gram substance gave 0.3189 gram AgCl.

	Calculated for $C_9H_6O_2NCl_3$	Found
Cl	39.92	39.43

On treating a glacial acetic acid solution of this compound with bromine a bromo derivative is obtained in large quantity. On cooling a hot glacial acetic acid solution it deposits

[1](Ber. 28, 2812).

in clusters of fern-like crystals which decompose at 237°. This body is under investigation.

Trichlorethylidenedi-o-aminobenzoic Acid,

$$CCl_3CH(NHC_6H_4COOH)_2.$$

Five grams (2 molecules) anthranilic acid in 40cc boiling benzene were treated with 2.9 grams (1 molecule) chloral in 10cc benzene and boiled under a reflux condenser for three hours. During the boiling there separated 3.25 grams of the di-compound, melting at 164°-165°. On cooling a further yield of 0.6 gram was obtained. On evaporation to dryness the residue was found to weigh 4.0 grams and to melt at 157°. The pure body melts at 165°. The method of Niementowski[1] was tried and although found to be better than for the preparation of the mono-compound it gave a smaller yield than our method and a larger amount of unknown colored by-products.

Analysis:

0.5000 gram substance gave 0.0410 gram NH_3 (Kjeldahl).
0.2000 gram substance gave 0.2113 gram AgCl.

	Calculated for $C_{16}H_{13}O_4N_2Cl_3$	Found
N	6.96	6.76
Cl	26.11	26.10

The di-compound consists of a crystalline powder and may be purified by precipitating its ether solution with ligroin. Upon boiling eight hours with acetic anhydride and cooling, a crystalline substance deposits, melting at 183° and crystallizing from benzene in needles. This corresponds to acetyl-o-aminobenzoic acid. On treating a glacial acetic acid solution with bromine there is almost instantly obtained a heavy precipitate which after recrystallization from glacial acetic acid melts with decomposition at 236°. This behavior is surprisingly like that of the bromo derivative of the mono-anthranilic acid compound.

[1](Ber. 35, 3898).

CHLORAL AND o-TOLUIDINE

Trichlorethylidenedi-o-tolamine,

$$CCl_3CH(NHC_6H_4CH_3)_2.$$

With Strowd Jordan. Chloral and o-toluidine were brought directly together in the proportion of one molecule to two molecules. No advantage was found in using benzene as a solvent. 19.3 grams chloral were added to 28 grams of o-toluidine, the mixture turned dark red and the temperature rose to 80°. After standing for some time, often over night, a quite hard crystalline cake formed. This was dissolved up in ether or successively extracted with benzene. In either case, a small residue weighing 0.7 gram remained. This was pale greenish in color and melted at 213°. The main product of the reaction was recrystallized from ether until the melting point reached 80°.

The yield was 70 per cent of the theory.

Analysis:

0.1763 gram substance gave 0.2194 gram AgCl.
0.2000 gram substance required 0.2915 gram $AgNO_3$.
0.2000 gram substance required 0.2973 gram $AgNO_3$.

	Calculated for $C_{16}H_{17}N_2Cl_3$	Found		
Cl	30.95	30.77	30.40	30.96.

The Stepanow method[1] was employed in the second and third analyses and found to be extremely convenient. With some of our compounds we have found it impracticable on account of the deep color of the solution. We found it advisable to adopt the suggestion of Rosanoff and Hill[2] and filter off the silver chloride before titrating.

Trichlorethylidenedi-o-tolamine crystallizes in very long silky needles. It is not very stable in solution or when ex-

[1](Ber. 39. 4056).

[2](Jr. Am. Chem. Soc., 29, 269).

posed to the light. It is decomposed by water into chloral and o-toluidine. It is soluble in cold alcohol, ether, acetone, chloroform, carbon tetrachloride, carbon disulphide and glacial acetic acid. It is soluble in hot ligroin, benzene and methyl alcohol. The pure substance melts at 80° and will melt repeatedly at that temperature. A bromo derivative is readily obtained in glacial acetic acid solution. It forms silvery white plates which melt with decomposition in the neighborhood of 268°.

PHYSIOLOGICAL ACTION.

We were led to a study of the physiological action of the trichlorethylidenedi-o-tolamine by an accidental observation. Mr. Jordan unintentionally got a small quantity in his mouth and within a few hours there followed a marked physiological action. A preliminary test has been made upon two rabbits. Dr. William DeB. MacNider of this University kindly carried out the test for us in the pharmacological laboratory of the University of Chicago. A 5 per cent dilute alcoholic solution was employed. This was first used in 10cc doses, intravenously. It produced at first a slow heart action accompanied by a slight fall in blood pressure. Following this initial change the respirations became accelerated, the heart action fast and the fall in blood pressure much more pronounced. Doses of 25cc given by the stomach caused the animal to become drowsy, inactive and imperfectly responsive to stimuli. The respirations were accelerated. One rabbit returned to a normal condition in six hours. The other animal, receiving the drug by the stomach, died apparently from respiratory failure. A more complete study is under way upon a large number of rabbits. This study will be extended to other diphenamine derivatives of chloral.

Chapel Hill, N. C.
Oct. 16. 1907.

RECENT CHANGES IN GOLD MINING IN NORTH CAROLINA THAT HAVE FAVORABLY AFFECTED THIS INDUSTRY

BY JOSEPH HYDE PRATT AND A. A. STEEL *

Before taking up an account of the changes that have been recently introduced in gold mining in North Carolina, it may be of interəst to mention some of the causes for failure in the profitable mining of gold in this State, as the changes to be described hav to some extent at least modified and lessened the chances for failure.

Many of the causes of failure in North Carolina gold mining can be traced to a lack of adequate capital, which prevents mining from being conducted in the most economic manner. O ne of the most noticeable of these is the tendency to sink the shafts but 15 to 30 feet before driving a new level and then stoping out a small block of ground instead of having the levels from 75 to 100 feet apart. Since a ton of ore removed in driving the level even in a wide vein will cost fully twice as much as a ton of ore in stoping, it is obviously more economical to have as few levels as possible. It it becomes dificult to make the raises more than 100 feet and is expensive to get men and timbers into much higher stopes. Therefore, the levels should not be over 100 feet apart. In a narrow vein where much waste could be left in a stope, the economy is greater. Somewhat similar to this is the habit of sinking a number of shafts close together instead of only one or two on a vein. This is not so bad for working ore

* Published with the permission of the State Geologist of North Carolina

near the surface, but becomes very expensive as the mine gets deeper, especially when hoisting machinery is required on each shaft. This is partially explained by the fact that many of the old mines have been worked at very irregular intervals and the old shafts have become caved in during the period of idleness.

Even those mines having capital are often badly managed. They frequently put in machinery of unnecessarily large capacity, not realizing that a very small engine and bucket can easily get out 10 or 15 tons of ore per day and keep a five stamp mill busy. There are many little mines that could pay a profit under careful management with five stamps and running only one shift; but some of them have engines big enough to hoist four times as much ore. Since the engineer and top men must be there all the time, there is no economy in operation but may even be a loss, since the engine cannot work steadily and fuel is wasted keeping up a big fire; and' of course, the first cost is greater. If the mine ever gets much too big for the small engine, it can be used in prospecting or underground work.

A great many shafts are much to big. It is not uncommon to see a little bucket, 30 inches accross dangling in the middle of a hoisting compartment 6 feet square in the clear, It is considerably cheaper to sink a shaft with compartments only 4 feet square in the clear and when the hoisting compartment is smoothly lined with plank (to assist ventilation), or fitted with guides, it has jnst as great a capacity — usually more than enough for the output of the mine. If necessary, the hoisting capacity of a shaft may be greatly increased at any time by putting in a tall bucket, or better a self-dumping skip and high speed engine. The ladder and pipe compartment is often as big as 6 by 8 feet. Since the cheaper and better direct acting steam pump would now be placed in a shaft, instead of the clumsy and bulky Cornish pump, the water, steam and compresed air pipes take up very little room. It is now customary to put in slanting ladders between landings some distance apart. They can almost as well be a little

steeper and shorter and go in a smaller space. The men will always ride up in a bucket, fitted with a crosshead running in proper guides or running in a closely planked compartment if the shaft is crooked. Therefore, the ladderway is an emergency exit only and a good, continuous vertical ladder securely fastened against one wall of the compartment is all that is needed, and the compartment for ladder and pipes may seldom need be over 3 by 4 feet. The two compartments and the division between them then need be only 4 by8 or 3½ by 7 feet inside. Besides being much more cheaply and rapidly sunk, the small shaft need not be so heavily timbered, since the shorter timbers are stronger and the earth pressure tends to arch around the shaft instead of coming fnll upon the timbers. On the other hand, the first 6 by 10 feet (8½ by 12½ feet outside timbers) shaft at the Montgomery Mine, at Candor, Montgomery County, became useless after about 5 years from the buckling of the timbers, although splendidly timbered with 12 by 12 inch oak sets, which showed no signs of decay.

There is, of course, very seldom any need for more than one hoisting compartment, since the saving in power will only pay for the greater expense of engine and shaft when a large amount of ore is to be hoisted from considerable depth. When a single large skip will handle all the ore, there is no need of putting in another to remain idle half the time.

Timber framing for shafts and tuunel sets is often unnecessarily complicated and the carpenter must waste mnch time chiselling, when simple notches laid off with a square and cut by saws are often stronger and always more easily made.

The most disastrous error is usually great haste in putting in a mill or smelter. It seems that the first thing that many miners think of after finding a little good ore is to stop work in the mine and put in a mill; so there are mills which have been able to run less then a month before the mine was exhausted. There is usually a neighboring mill to which thə ore might as well have been hauled. It is seldom that tests are made to tell what sort of a mill and treatment is adapted

to the ore. Unless the ore body is large, no mill should be installed until the changed ore below the water level has been tested.

In North Carolina there seem to be only a few miners who deceive themselves by assaying the rich streak and assuming that the entire streak will be equally as good. The general principles of sampling the entire body seem to be well understood, although it is not always done as accurately as it should be.

Even when good ore occurs in paying quantities the miner frequently builds a mill that is too large; For there is only a little extra expense in increasing the size of the mill after it has been running awhile instead of building a large mill all at once. So there is little excuse for assuming the greater risk of a large mill. There is less loss of gold in adjusting a small mill.

One agreeable exception to the practice of building a mill before the mine is sufficienty developed is seen in the work of the Whitney Company, who have carefully tested and explored a number of mines. Many of the options were given up of course. At the old McMakin Mine at Gold Hill, as explorations proved the value of the mine, the contemplated scale of working was gradually increased. When the small shafts of the upper levels were deepened, the lower parts were made large enough for balanced hoisting and the small part will be enlarged later. In the meantime most careful sampling and assaying was done and when enough ore had been blockedout, careful mill tests were made chiefly upon the material obtained from drifts. In this way a total of 4,950 tons of ore was run through the little mill on the ground; careful records of everything gave an average recovery of \$4.52 of gold on the plates and only \$0.34 per ton as a concentrate worth but \$5.03 per ton and \$0.83 per ton in the tailings. These tests made clear that the most economical method is simple amalgamation, giving a saving of about 80 per cent of the gold, with no attempt to concentrate and treat the concentrates.

The two main shafts are down 800 feet and another is 400 feet deep, with the levels averaging over 700 feet long. This work shows a vein averaging 14 feet wide and gives a million and a half tons of ore blocked out ready to stope, and which will yield $2.50 per ton by amalgamation. They have accordingly planned a mill large enough to treat 1,000 tons of ore per day, making the estimated total cost of mining, milling and transporting the ore only $1.48 per ton. They are now waiting for the completion of their water-power plant before building the mill and since they have sufficient ore blocked out, the mine has been idle and full of water since the spring of 1905. The intention is to keep a reserve of 500,000 tons of ore in advance of the stoping.

The Bonnie Doone, or Old Smart Mine, has also been properly developed by Mr. J. C. Bates, a former owner of the Howie Mine. The old 80 foot shaft has been deepened to 200 feet, with levels 125 feet long at 60 feet, 100 feet at 120 feet, 160 feet at 186 feet. The ore obtained from these workings is now piled in a large dump estimated to contain 3,000 tons. And before the mill was planned, this was carefully sampled by a competent mining engineer, who dug deep trenches across it and found it to average $15.00 per ton. Of course a great deal of the same quality of ore has been blocked out in the mine. There are about 500 tons in another dump of material which came from work in the walls and is chiefly slate but contains a few of the veinlets and masses of milky quartz, and is said to assay about $1.50 per ton. It has been kept out of the good ore at only a nominal expense. The mill has not been built on account of the continued sickness of the owner, so there is no machinery at the mine except the sufficiently large prospecting hoist.

As an example of a mill too large for the development may be mentioned the Reimer Mine, near Salisbury. Here a 20 stamp mill with chlorination failed simply because no ore at all had been blocked out and it could not be mined rapidly enough to keep the mill going. An examination of the mine by the late Mr. Parker, mining engineer for the Whitney

Company, showed a remarkably continuous vein, averaging 3½ feet wide and carrying $7.50 in gold.

Mr. Parker planned to develop the mine so that it might easily yield 50 tons per day, so the total cost of mining and treating the ore would be about $4.50 per ton, which includes depreciation, etc.

The general custom of having no reserves of ore blocked out prevents conservative mining men from investing in them, since there is no way of determining the value of the vein unless it is opened up. It would be much better to spend the cost of a premature mill in developing ore so that there would be no difficulty in securing capital or selling the mine to advantage.

It is also quite customary to extract all of the ore by underhand stoping. This becomes very expensive when the vein is so narrow that some of the wall-rock must be broken to make room, or when the vein contains much barren rock. All of this waste material must then be hoisted to the surface and much of it becomes mixed with the ore in the bins and chutes. If the stopes are mined upward or overhand, all the waste can be left in them supported on a single line of stulls over the drift. This often affords a scaffold for the men and so saves the great expense of putting in many stulls. In addition a large block of filling will serve as a pillar to hold the walls apart so no ore need be left in the mine. One excellent mine superintendent said that the reason for this was the fact that most of the miners are more properly farmers and cannot drill holes upwards. They do not work steadily enough to warrant an attempt to teach them how, even though skilled men prefer to drill "uppers." This objection can be overcome in those mines having air drills for driving levels by installing a few of the blockholing or air hammer drills which may be held in one hand and, besides being much quicker, can be worked in stopes too narrow for hammering by hand. So far there seems to be none of these machines in North Carolina, although they are becoming standard in the west.

When the mines yield rich ore in narrow streaks, it should be hand-picked before going to the mill. For this purpose the Miami Mining Company have installed at the Phoenix Mine, near Concord, Cabarrus County, an ore picker. The ore is sorted into coarse and medium material by passing through a trommel, where it is also washed by a spray pipe. It then passes over a couple of belts 30 inches wide and 30 feet long. A number of boys sit along these belts and pick out the waste, which is removed by another belt, while the good ore passes direct to a Dodge crusher. The dirt and fine ore removed by the water is raised by a sand pump directly to the battery. These machines would not pay at a small mine where an arrangement like that at the Hercules Mine at Cid, Davidson County, is better. Here the ore is dumped from the skip on to a slightly elevated platform, where it is washed by a stream of water from a hose and the waste thrown into a car standing near, as the good ore is shovelled into a car for taking it to the mill.

Since the publication of Bulletins Nos. 3 and 10 of the North Carolina Geological Survey, there have been a number of changes in mining practiced in the State, which, given in the order of their probable importance, are:

1. The application of machines of the old log washer type to separate gold from saprolites as is now being practiced at the Shuford, Empire, Beaver Dam, Troy, Sawyer and other mines.

2. The introduction of square set timbering in the extraction of soft, deep ore bodies, which is now being practiced at the Union Copper Mine at Gold Hill.

3. The introduction of the cyanide process for treating certain sulphuret ores, which has been practiced on the tailings trom the Iola, Montgomery and Howie mines.

4. The introduction of self-dumping skips, picking belts etc.

LOG WASHERS

Perhaps the most important change to be noted in gold mining practice in North Carolina is the introduction of log washers in treating many of the saprolitic ores that are found quite abundantly throughout many portions of the State. The old principle of the log washer cannot be patented, but the machines that are now being used, known as modern pulverizing concentrating machines, possess many mechanical improvements that adapted them to the work that they are called upon to do.

Each separate unit of these machines consists of two improved log washers running at high enough speed to readily disintegrate the soft material and so mix the clay into a fine pulp with water that the gold can readily settle to the bottom. Each machine is essentially a long trough or boiler plate containing a revolving cylinder fitted with heavy white iron arms set spirally so that the ore, while being hammered fine, is gradually worked to the discharge end. At the end of the first washer, the larger, hard and nearly barren quartz stones are removed by a revolving screen and belt conveyor, this being done to save wear and power in the second washer, where the gravel is still further reduced in size and more gold settles out. The gravel that remains after passing the second washer is removed by a finer screen and the chief pulp, free from stones, passes from the riffled sluices about three feet wide and of varying lengths, which contains mercury to amalgamate and save any free gold that does not settle in the machine.

The steel troughs are about 2 feet wide by 2½ feet deep, the first being 18 feet long and the second 12 feet, with a semicircular bottom and a flat wood top. The revolving cylinder is made of an 8-inch steam pipe carried upon a heavy steel shaft, passing through stuffing boxes at the ends of the trough. Wrought iron bars reach through this pipe crosswise and project about 3 inches on each side to form legs to which 8½ inch cast iron arms are bolted to take all the wear. There is about 4 inch clearance between these arms and the

bottom of the troughs, which allows the formation of a bed of stones, which reduces the wear on the bottom and helps save the gold. This bed of stones is of course more or less shaken up by blows from the large fragments of quartz and by the revolving arms, thus permitting the gold to settle through as in panning. The constant striking of the paddles against the surface of the water will also weight and sink some of the float gold. The discharge end of the machine is set 6 inches higher than the feed end so that the gold, once down amongst the pebbles of the bed, is not apt to be pushed out.

Riffles of the sluices are made by boring inclined auger holes in the planks laid lengthwise in the cement-lined sluice boxes. Since all the coarse gravel has been screened out, there is little wear upon the riffles and the fall and quantity of water are less than in the regular sluice for hydraulic mining. In cleaning up, the planks are lifted up and turned over and the gravel and mercury washed to the end of the sluice where quicksilver and amalgam are washed out in hand pans. When through cleaning up, the planks are simply replaced and the riffles filled with mercury and the machine started again.

In cleaning the washers, which is usually done twice a week the machines are stopped and all the gravel within washed out with a hose through an opening in the bottom. This gravel is then panned by hand and the gold amalgamated. Any nuggets that occur in the rock are pounded free from quartz and are then also amalgamated.

The amalgam from all sources is strained out of the quicksilver and then retorted and the bullion sold.

The chief wear on the machine is the arms, which under certain conditions, as on the sharp ore at the Shuford mine, only last six weeks. They can, however, be readily made at any foundry.

It is recommended by the maker that the first washer be driven at 150 to 250 revolutions per minute and that the second one at 250 to 350 per minute and that for a capacity of 10 tons

per hour, each machine be given 72 gallons of water per minute. This will then at times require 25 H P. for a complete unit of two washers and trommels. These factors will vary greatly with the character of the ore. Since the power, and therefore the wear, will increase even more rapidly than the square of the speed, this should be kept low. In the absence of any coarse stones, there is also danger that the pulp may be too greatly agitated to allow the settling of the gold. On the other hand, the speed and work must be sufficient to grind up the ore. If there is too little water, the clay paste may not allow the gold to settle. If there is too much, there is a danger of the gold being washed out. While a large capacity is of advantage and desirable, still it will mean danger of insufficient grinding, too thick pulping, or too strong a flowing of water. A great deal of skill and patience is, therefore, required in adjusting these fixtures, but when once adjusted, they will work satisfactorily. It is to be recommended that a first unit be installed and run over several months at various speeds, capacities and amounts of water and the machine should be given plenty of time after each change of condition to adjust itself. Also, careful tests of the ore and tailings should be made between times. The capacity and speed should first be adjusted until the best result is given in reducing the amount of gold left in the tailings so combined that it will not pan. The pulp should of course be kept at a reasonable consistency throughout the changes and the amount of water finally adjusted so that the tailings will show a minimum of free gold in the pan.

These machines are made in Knoxville, Tenn., and are handled by Geo. L. Erdman, of Asheville, N. C. One of the first of these machines was installed at the Shuford Mine, owned by the Catawba Gold Mining Company, and situated about three-quarters of a mile north of the post-office of Edith, about 5 miles south-east of Catawba Station on the Southern Railway. They have a plant of 4 double units. The Company are operating on a tract of land containing a gold-bearing zone said to be 2 miles long and 600 feet wide.

This will all pan gold at the surface and has been tested by bored holes 30 to 50 feet deep to water level and by one old shaft 115 feet deep. This zone is filled with small quartz seams from a line to occasionally several inches thick and having all possible strikes and dips and seldom more than two feet apart in every direction. The country rock varies from schist to gneiss and is generally heavily stained by iron oxide and thoroughly decomposed, except for a few, bold outcropping hard masses. The quartz is usually thoroughly honey-combed and broken into soft, angular fragments. Except at the surface, most of the gold is in these quartz streaks, but the hard and solid portions of them seldom have much value. At the present time the entire mass is being mined by means of an irregular pit which was, in the summer of 1906, 90 feet deep and 250 to 300 feet across at the top. The material at the bottom is just as soft and decomposed as at the top and the ore is loosed by black powder and shovelled by hand into cars containing a cubic yard. The cars are hoisted up a steep incline and automatically dumped over a grizzly of light steel rails. The fines are washed through the grizzly by jets of water, the soft large lumps being crushed and knocked through by means of a pick. In 18 months operation only a few tons of large, hard lumps have thus far been thrown out. The material is then washed down a trough about 50 feet long, thus becoming pretty uniformly mixed before being divided among the washers. At this mine the machines are run at only 150 revolutions per minute. They were tried at a lower speed, but there was trouble with the gold sticking to clay balls. The machine used about 150 gallons of water to the minute and the whole plant is run by a 35 horsepower engine which, when the three units are running, is probably overloaded. The tailings, when tested, usually pan nothing at all, but assay a few cents, due to gold included in the sand. While this loss could be reduced by speeding up the second washer to grind the sand finer and trusting to the riffles to save what little additional free gold would not then settle in the machine, it

is doubtful whether with the present small plant and so vast a quantity of ore controlled by the Company such refinements are advisable, since they would probably reduce the capacity of the plant. It is estimated that the present cost of treatment is 22 cents per cubic yard loose measure with a recovery of between 50 cents and $1.00 per cubic yard.

A great deal of the success of the Catawba Gold Mining Company is due to its conservative policy and the skill with which the whole mining and milling operation has been conducted.

The next machine to be placed in operation was at the old Laflin Mine, near Cox, Randolph County, about 4 miles east of Cid Station on the Thompsonville and Glen Anna Railway. The Empire Mining Company own a tract of land which contains argillaceous slates containing two gold-bearing zones, 200 feet wide by ½ mile long, the northwest zone being along the south side of a hard quartz and siliceous slate vein. The early work on this property was done at the northeast end of the northwest zone where there are several large pits, some 50 feet deep. The entire surface was tested by pan assays (weighing the amount of gold from known weighed amounts of ore) and a number of trenches were dug across the better portions of the zone. The results of this test led the Company to instal their experimental plant on the gentle slope to another stream near the southwest end of the northwest zone. At the other end the slates are still soft at a depth of 50 feet, but here they were found to be quite solid and tough within 6 or 7 feet of the surface, though drill holes are said to have proved that the rock is again soft below a 5 or 6 foot shell of hard material. The dip at this end is only 15 or 20 degrees instead of being nearly vertical as at the other. This tough slate is thoroughly oxidized and shows a very uniform distribution of wheat-like grains of limonite, formed from pyrite, which lie along the cleavage planes of the slate and all the gold occurs in them.

This small branch has a steep fall for 2 miles to the Yadkin River and for the experimental plant water is returned

from a small settling pond nearby. In order to get sufficient fall for the head and tail sluices, the machines are put pretty high up on the hill so that a fat incline has been put in with dumping arrangements, etc. similarly as at the Shuford Mine. The ore is broken up by hand into about 3 inch cubes and when not hard, there is some tendency for it to stick in the grizzly crusher owing to the large percentage of clay, which is often moist. The first machine is run as high as 250 revolutions per minute on hard rock, but was found to give best results on average partly decomposed slates at 175 revolutions per minute. As there is no hard quartz in this ore, there is no need of an intermediate trommel. The second machine is operated at only 90 revolutions per minute and saves most of the gold, which is very fine. The trommel which follows this washer removes practically nothing but fragments of tree roots, which shows that everything is ground below 4-mesh. The riffles are 64 feet long, but very little gold is found below the first 20 feet. With this soft, clayey ore the capacity is about 8 tons per hour and 110 gallons of water per minute are required. In the summer of 1906 the machine had hardly passed the experimental stage, but the tailings almost never showed any free gold and assays of carefully taken samples showed a recovery of 90 per cent of the soft material and 80 per cent on the hard.

A few modifications of the machine have been made by Mr. O. K. McCutcheon, Superintendent of the Empire Company, by introducing an improved stuffing box and valve for the clean-up openings and in the second washer iustalling a plate 9 inches wide and one inch above the center of the bottom with cross-lots ½ inch by 5 inches. This false bottom is curled up at the discharge end and serves as a riffle plate, thus considerably increasing the recovery of very fine gold.

One double unit of these machines was being worked on the property of the Troy Mining Co., 7 miles north of Troy, Montgomery County. There are some old shafts, but the two main workings are based upon recent discoveries. By test pits and panning it seems there are two parallel zones of

slate bearing gold. Open cut No. 1 shows white and pink, clay-like slates with iron stains and abundant limonite cubes and seams. The direction of the slates is N. 45° E. and part of the material seems to represent thoroughly decomposed, sheeted, coarse grained porphyry so that the deposit is probably on a contact. The values are not uniform and at a depth of about 12 ft. the deposit seems to be about 20 ft. wide, 50 ft. long and the upper part of a rounded lens, richest in the center, where a 25 ft. shaft is said to have produced $30.00 ore. To develop deeper, a shaft was sunk in the hanging wall. At a depth of 70 feet, it was stopped just as it began to cut light-colored, sericitic schists, carrying pyrite.

The material from open cut No. 1 was all conveyed by a sluice to the mill, a short distance away. Although a good deal of gold was saved, the tailings ran $3.00 a ton and tests were stopped.

Open cut No. 2 was made by recent unsuccessful hydraulic mining. It was, at the time of the visit, 200 feet long, 20 to 24 feet wide and 2 to 10 feet deep. This zone pans quite uniformly 18 to 20 feet wide in the cut and in cross trenches beyond the end of it. No assays of average samples have been made. There is a barren, white quartz vein, with some large quartz crystals, along part of one side of the zone and most of the material seems to have been more or less siliceous sericite schist, now thoroughly decomposed to purple clay or fine sand. At the time of the visit, 100 tons were being hauled over muddy roads to the mill about a quarter of a mile away, to make a test run.

The machines were found to give a little less free gold in the tailings as the speed was reduced, and at the time of the visit, both sections were being run at only 60 R.P.M. The rate of feeding is very low, apparently only 2 tons per hour, and the amount of water is very large, apparently about 150 gallons per minute. As there was no hard pebbles or other material in the ore to form a bed in the machine, it is probable that most of the gold was washed out. Even at this low rate of speed the coarsest tailings were very fine

particles of sand. Samples of the tailings included only the coarser, rapidly settling parts, so that the assays made were probably too high. It may be that the slower speed simply decreases the pan assay of the tailings by not freeing such a large percentage of gold which remains included in the larger grains.

The most apparent recommendation would be to put McCutcheon riffles in the bottom of the machine, run the first machine faster than the second and greatly increase the percentage of ore fed to machine as compared with the amount of water used. No samples of the ore had been taken so the tests are not conclusive.

The latest reports are that the tailings from open cut No. 2 also assayed $3.00 to $4.00 per ton; that the washers are abandoned and that a 50 ton cyanide mill will be erected. It is also said that some good ore was struck below a quartz vein in a 17 ft. shaft, sunk in open cut No. 2. It is probably well to abandon the washers here because the thoroughly decomposed soil gets very hard not far from the surface, and the water level will be less than 30 feet below the highest part of the ore zone now exposed. Therefore the available tonnage of decomposed material is rather small. A shaft on a third vein, just below the creek bed, shows hard silicified sericite slates, with much pyrites but no visible copper or other minerals which would interfere with the cyanide plant adapted for handling slimes.

Machines have also been installed at the old Sawyer Mine in Randolph County 5 miles west of Sophia and about 14 miles from High Point. This property has been worked off and on for many years, but has failed because the gold could not be saved by a stamp mill and plates. The machine will first treat the soil and very soft outcrops and then the hard rock, which does not slack by itself will be crushed fine by rolls and the machine used simply as a panning device. This will be a new and novel use for this machine and the results will be watched with interest.

The McCutcheon modification of the Modern Pulverizing and Concentrating machine is being installed at the old Mer-

rill Mine on Carraway Creek 3 miles west of Sophia. The old workings are said to show a zone 1-2 mile long which is composed principally of clay to a depth of 50 or 60 feet. There are eight long cross-cut trenches and many test pits have been made which are said to have given ore running from $1.50 to $1.90 per ton.

Near Newton, Catawba County, one of the machines is being installed to work a property said to be similar to the Shuford Mine in the same county.

From information obtained by observation in the field and tests in the laboratory, it would seem that this Modern Pulverizing and Concentrating machine is adapted for certain ores such as those of the Shuford Mine and that with certain modifications as have been worked out by Mr. McCutcheon, the machine can be adapted to still other ores. It is necessary, however, to make a careful study of the ore and to adjust the machine to each particular ore before it can be determined whether or not the machine will save the gold; and a machine should not be accepted or discarded until the ore has been thoroughly tested to ascertain whether or not the machine can be adapted to that particular ore.

SQUARE SETS.

The second change in mining practice of great importance to the gold mining industry in North Carolina is the introduction of square set timbering in the extraction of soft deep ore bodies. This method was introduced by Mr. H. L. Griswold, superintendent of the Union Copper Company's mine at Gold Hill, N. C. In former mining the old stopes were held open by miscellaneous timbering such as stulls, lock sets and truss sets. Such methods were not satisfactory and prevented the stoping of the ore in the most economical manner. By the introduction of the western square set method of timbering, the stoping of the ore is being done safely, completely and economically. The sets are made of 8 x 8 inch sawed oak and the mine carpenter can usually easily frame enough timber for this work in about one-eighth of his time. The

sets are 6 ft. 3 inches high in the clear and 5 feet across in the clear. The posts are, therefore, 6 ft. 3 inches long between the shoulders and have a 5 x 5 inch tenon 1½ inches long at each end; the caps are 5 ft. 3 inches between shoulders and have a 5x5 inch tenon 2½ inches long at each end; the ties are 5 feet between shoulders and have a tenon 5x8 inches and 1½ inches long at each end.

The size of the timbers will of course vary with the weight to be sustained. This style and proportions of framing are very good for oak timbers; but for pine, which crushes so easily across the grain, it is better to have the ends of the post tenons to touch each other. The light timbers are of course cheaper and much more easily handled. As the stopes get large, they are more or less completely filled with waste rock which is usually obtained in mining and would otherwise have to be hoisted out in working the usually underhand stopes. This filling also holds the posts in position and helps to prevent them from buckling or "jack-knifing" if any one timber yields, which might otherwise endanger the whole system. Since most of the pressure is downward, as soon as the ore is blasted away to make room for a new set, all the sets below are relieved and tend to come back to their original position. Thus, even light timbers will hold very well if the stope is worked rapidly enough.

In the Union Copper mine the square sets were founded upon a platform built upon the old solid looking truss sets. As soon as a heavy load came upon them the trusses buckled sidewise and everything caved in. A new foundation was then made upon reinforced stulls and there has been no trouble since. Mr. Griswold is starting a new lot of square sets in a large open chamber just above the fourth level and he will thus be able to work out easily all the ore left above, especially a big pillar that remains between the first and second levels.

A new set can be added in any position at any time without disturbing the adjoining timbers and the old timbers can easily be supported by temporary props while making room

for an additional set. When the old timbers have been replaced the entire flooring of sets is easily put in as the ore is removed; a temporary plank covering may be placed across the old timbers to protect the men from falling rocks. Temporary plank floors are placed upon the sets for the men to stand upon and, as the system becomes higher, chutes and mill holes are put in to conduct the ore to the car on the track below. Any waste rock mined is merely dumped in and around the lower sets.

There has been little or no trouble indtroducing the square set method of timbering and at the Union Copper Mine the work is done under the immediate supervision of Mr. Hedrick, a skilfull North Carolina shift boss who has had no previous experience with square sets. Some of the miners, especially negroes, when first stoping by means of square set timbering are a little nervous because they are so close to the roof that they can see how loose the rocks are; but they soon realize that they can pick down the loose rock or prop it up and, therefore, are safer than when they are so far away that they cannot tell at what moment the rock may fall upon them. Also when working at the bottom of a high, underhand stope, a blow from even a small rock would be dangerous.

CYANIDE PLANTS.

The introduction of the cyanide process for treating certain sulphuret ores is a third change in mining practice in the State that has added considerable to the production of gold. One of the most successful cyanide plants was the one erected to work the tailings of the Howie mine, near Waxhaw, Union County. This mine is in a zone of hard, siliceous slates, carrying chimney-like bodies of pretty high grade ore. The gold is all free but so finely disseminated that the high grade ore which is a laminated or schistose quartz has merely a golden sheen. A great deal of this escaped amalgamation although enough was saved to pay well. These old tailings, which are rumored to have been worth 5 or 6 dollars a ton, soften

somewhat upon exposure to the weather so that the recovery by cyanide was very good.

The old cyanide plant had four iron tanks 5½ feet deep and 30 feet in diameter and supposedly the necessary other tanks and apparatus. When the tailings were exhausted the mine was sold to the Colossus Mining Company, a London corporation, which proposed to put in an immense plant to treat the entire zone. This zone had previously been cross cut by two trenches somewhat over 20 feet deep, but it was never properly sampled, for although there are many fairly rich streaks, the general average value is only 40 to 50 cents a ton. The tanks of the old mill were made a part of the new big mill, so the original arrangement of this successful plant could not be learned and also no one could be found to give information about the successful treatment. There is now a Ledgerwood cableway for economical handling of excavated rock. This dumps the skips of rock upon the feeding platform of a very large gyratory crusher discharging into a trommel. The coarse rock from the trommel goes through a smaller gyratory crusher into the bin cotaining the finer rock. From this bin it is hoisted to a long, rotating cylinder dryer discharging to the first of a pair of Allis rolls working in series with necessary screens and elevators. The fine material from these rolls is divided among three ball mills of peculiar design. They have a vertical axis bearing arms which push a number of six inch iron balls around a horizontal runway.

There are at present no screens on these, and the product contains a good deal of troublesome dust or slimes, and some sand too coarse for successful cyaniding. From the ball mills a fine set of conveyors carry the dry material to any one of the leaching tanks. There are six tanks 5½ feet deep and 40 feet in diameter, and four tanks 5½ feet deep by 30 feet in diameter, all in the open air; and the necessary solution, gold and slump tanks. The mill is very badly designed since the rolls have scarcely capacity for 75 tons per day and the ball mills were so overworked that much coarse sand passed

through them. On the other hand, the crushers, elevators, etc., have a capacity fully four times as great. The mill has been used by the present management in making cyanide tests upon the rich ore remaining in the chimneys. Even when crushed very fine this fresh unaltered ore can be leached for a week without apparently giving up more than half its gold, thus this cyanide plant cannot be used for this ore.

At present the most productive cyanide plant in this State is the one at the Iola Mine, near Candor, Montgomery County. The ore, coming from a pretty sharply defined vein, is either a hard, glassy, white quartz with traces of unreplaced slate, carrying coarse gold in octahedral crystals; or soft sugary, white quartz generally richer but not showing visible gold. This "sugar quartz" has lately been running from $14.00 to $20.00 per ton. It is crushed in a dilapidated 20 stamp mill where the coarse gold and much of the fine gold is amalgamated as usual. The tailings are elevated and are run to the various settling tanks or "sand boats," 3 feet wide at one end, 5 feet at the other, 12 feet long and 3½ feet deep, having at the small end a wooden lattice on the inner side of which a canvass curtain may be rolled up from the bottom. When the thin tailings run into this the sand settles out and the fine part or slimes flow into the slime tanks. As the sand accumulates the curtain is unrolled so that the overflow is just above the level of the top of the sand. The other two sand boats, just above the tanks, are plain boxes 6 feet by 3½ by 15 feet. One end is bored full of holes to let out the slimes. These are plugged as the level of the sand reaches them.

The wet sand from these boats is shovelled or wheeled into whichever of the sand tanks may be empty. This shovelling thoroughly breaks up any water tight layers of slime which may have formed when the mill was shut down for a short time, and the thin pulp remaining below the overflow has a chance to settle in a layer on top of the sand. It also supplies the needed oxygen to aid the cyanide in dissolving the gold. The sand tanks were made locally of yellow pine and

are 4 feet deep and 20 feet in diameter with the usual cocoa matting filter in the bottom. When filled to convenient height, they hold 40 tons of sand. A solution containing 1.4 pounds of potassium cyanide per ton of water is pumped upon this and drained off through the filter; this solution is kept circulating as rapidly as possible, keeping the sand always covered, for three or four days until the sand must be removed to make room for another batch. Then the solution is allowed to drain off, after which a little water is added to displace what solution remains in the damp sand. The sand is then washed out by a stream of water from a hose through an opening in the bottom of the tank into a trough or launder, to a settling pond where the sand settles out and the water collects to be pumped back again.

The slimes flow from the sand boats to one of the three agitation tanks 10 feet deep and 20 feet in diameter. Near the bottom of each of these is a slowly revolving paddle consisting of four well braced oak arms carrying pins. Some of the surplus water is drained off and a solution carrying 1 pound of potassium cyanide per ton of water (0.05%) is added. The agitation continues while the solution and slimes are drawn off at the bottom to a 4-inch centrifugal pump, thus thoroughly aerating and mixing it. This process continues until the tank is needed for more slimes. The solution is then pumped into one of the settling tanks 14x18 feet at a little lower level. Here the solid matter slowly settles out and the clear solution is drawn off. Sometimes the slimes are returned for a treatment with a second solution until they are finally sluiced out to waste. The solution from the sand tank, which now contains the gold, is passed directly to the zinc boxes; these have six compartments, 2x2x2 feet, with a side trough and a diaphragm for circulating the solution. This arrangement allows any one box to be emptied and cleaned while the solution circulates through the others.

From the zinc boxes the solution flows to the sump tank, 10x20 feet. Here more potassium cyanide is added to replace what has been consumed until the solution reaches the right

strength. This sump tank thus serves for a solution tank, from which the solution is raised by a small centrifugal pump to the sand leaching tanks. Most other mills have a small extra tank at the highest level in which the solution is made up and from which it flows by gravity to the sand tanks.

The clear solution from the slime settling tank is stored in the tank 24x8 feet. From this it flows through an eight compartment zinc box like the other one and to the sump and weak solution tank.

In the zinc boxes zinc from a mass of fine zinc shavings enters the solution in place of the gold which is precipitated as a black coating upon the zinc. Each month the zinc in the boxes is sifted and the fine stuff saved, and the coarse stuff returned to the box. The deficiency of coarse zinc in the first box is made up by taking some of it from the second, which is in turn filled from the third and so on. All the fresh zinc required is added to the last compartment, and, since much of the gold sticks to the zinc until it is all dissolved, most of the gold slimes are recovered from the first compartment where precipitation is also most active, as the solution passing through it contains the largest percentage of gold.

The gold slimes, or finely divided gold, containing small scraps of zinc, is melted in a graphite crucible to which a little nitre is added to oxidize the zinc and cause it to unite with the borax used as a flux. The melted gold is cast into bricks and sent to the mint.

All the tanks are in the open air. The pipes are wrapped to prevent freezing, and there is no trouble except that heavy rains increase the amount of solution which must be wasted and so cause a greater loss of potassium cyanide. The pumps, and the engine for driving them and the agitators, are housed in. In the same building is the room containing the zinc boxes and furnace for melting the bullion. About 4-10 of a pound of potassium cyanide is consumed per ton of ore. In the ore are no copper minerals or similar substances to consume cyanide.

Eight pounds of lime are added to each ton of tailings on its way to the cyanide plant. This is to cause the slimes to settle more readily and neutralize any acid which may be formed from the pyrites in the ore, and which would otherwise consume cyanide. The chief loss of cyanide is, therefore, in the solution that is wasted with the wet slimes.

There is required one solution man at $1.50 a day for each shift. If one-half of the steam used at the mill is charged to the cyanide part, the total cost exclusive of interest and depreciation is $0.90 per ton. The tailings from the cyanide plant contain about $1.00 per ton of gold. Since the sands from the mill had been carrying $4.86 per ton, there is a handsome profit in the cyanide plant—about $2.90 per ton treated. The cost of the plant was from $10,000 to $12,000. The loss in the tailings could be reduced by a longer treatment of the sands and the intention is to add two more sand leaching tanks for this purpose.*

At the Montgomery mine, which adjoins the Iola, there is another cyanide plant for treating tailings from a 10 stamp mill. All of the tanks are square. The stream of tailings is first separated into slimes and sands in a pointed box. Near the bottom of this box is a pipe out of which the coarse sand, which settles most rapidly, flows to the settling tanks, over the sand tank, while the slimes overflow at the top opposite the inlet. The slimes are not treated and the sand treatment does not differ essentially from that at Iola. The mine was shut down at the time of the visit so no data as to the cyanide treatment could be obtained. From the relatively greater tank capacity, the sand probably receives a longer treatment. The solution tanks and zinc boxes are inside the mill.

There is a new cyanide mill at the Southern Homestake Mine, 13 miles south of Thomasville, near Cox, Randolph County.

*NOTE—The data as to the cyanide treatment was mostly obtained from Mr. W. T. Sawyer, former superintendent, checked as far as possible by Mr. Jones, the present superintendent.

The ore passes over a grizzly, the oversize from which goes through a Blake crusher, and, with the fines from the grizzly, are elevated to a trommel screen above a small storage bin. The oversize from this trommel passes through a pair of corrugated rolls, then back to the same trommel, and so on, until it is all reduced to sand. The corrugated rolls chattered badly on account of the coarse feed; and the soft clayey ore tends to stick them so it will probably be better to use instead a number of smooth rolls in series.

The fine dry ore is taken by a belt conveyor to one of the three sheet iron leaching tanks, 6 feet deep and 30 feet in diameter. It was assumed that the solution would percolate through the 5½ feet of dry crushed ore, even though the slimes were not removed; but in the actual tests the tanks were filled only half full. Below the level of these leaching tanks are zinc boxes and sump tanks; the three solution tanks are on a trestle outside the main building, covering the leaching tanks.

The property was purchased without adequate sampling and the work was abandoned after treating 150 tons and finding that the ore averaged only $2.00 a ton. No data as to time of treatment, strength of solution, etc., was obtained. The recovery on the three tanks tried was 70, 80 and 83 per cent respectively. The ore is decomposed rock, occurring in wide zones and carrying a great deal of clay. No data was obtained as to the capacity of the mill.

MINING DETAILS (SELF-DUMPING SKIPS, ETC.)

Many of the mines in North Carolina are based upon more or less flat veins and since most of the ore is hoisted in buckets, it is customary to sink vertical shafts. When the mines become deep, this requires expensive cross-cuts to reach the vein; hence there are many vertical shafts which are turned upon reaching the vein and not adapted to the use of a cage or an ordinary style skip. Mr. Geo. E. Price has overcome this difficulty at the Rudisill Mine, at Charlotte, Mecklenburg County, by modifying the ordinary skip, and

adapting it to his special needs. The shaft is vertical for 200 feet and then inclines at an angle of 35° from the horizontal for 150 feet more. The skip is the ordinary iron skip, except that the wheels are a little larger than usual to reduce friction on the incline and all have narrow treads. In the vertical part these wheels run between two vertical guide timbers. The rope is not over the center of the shaft but toward the dumping side so that when the skip reaches the top the front wheels run down the forward curve of the track until they strike the top. Then the rear wheels swing to the rear in the arc of a circle. Just before they reach the top of this arc the nose of the skip strikes a roller which raises the front wheels sufficiently to bring them to a bearing against the front vertical guide so that in case of overwinding the skip rises at the dumping angle and rock cannot be dumped down the shaft. In this way the skip need wait at the top of the shaft only long enough for the ore to slide out of it, which is but a small fraction of a minute.

The ore is dumped from the car on to a platform about 3 feet below the level of the rails and the skip is stopped with its top about level with this platform and nearly filling the opening in it. If the output of the mine was a little greater, Mr. Price would replace the platform by a small bin, into which the cars could be dumped as they reach the station and from which the ore could be rapidly run into a skip through a chute. But since the man that would be required to operate the gate has ample time to shovel all the ore into the skip, there would be no labor saving in the bins and no justification for the expense. For even a small mine this skip saves the labor of a top man.

In the ordinary vertical shaft the bales of the skips are fitted with shoes and there are no wheels on the skip which is unlatched and dumped at the top by rollers striking suitable curved guides. Such a skip has the advantage of needing only one set of guides and no wheels, but it cannot be operated around a curve.

The labor of the top.man is also avoided by a self-dumping bucket observed at the Haile Gold Mine, South Carolina. This is an ordinary bucket fitted with guide wheels. The back wheels are caught by a latch at the dumping place and turns over when the rope is slacked off. Then the bucket is raised, the latch is withdrawn by the engineer and the bucket lowered.

CHAPEL HILL FERNS AND THEIR ALLIES

The accompanying list of ferns of this region, including an area of about two miles radius around Chapel Hill, has been in course of preparation for several years, and is now, in all probability, very nearly complete. The topography of Chapel Hill is quite favorable to fern growth, and the number found here is as large as could be expected in regions free from limestone.

In his "Catalogue of the Indigenous and Naturalized Plants of the State," by Dr. M. A. Curtis*, there are given thirty-eight true ferns and eleven fern allies for the State of North Carolina. Of the species mentioned by him, eighteen ferns and four fern allies occur in Chapel Hill, while two of the ferns in the following list are not recorded by Curtis for this State. These are Botrychium obliquum var. dissectum, and Dryopteris Goldieana var. celsa.

The list of our ferns is as follows:

BOTRYCHIUM OBLIQUUM MUHL. (B. ternatum Chapm.). Ternate Grape fern. Not uncommon in damp, shaded places.

BOTRYCHIUM OBLIQUUM VAR. DISSECTUM. Dissected Grape-fern. Found only once in a low place near Judge's spring.

BOTRYCHIUM VIRGINIANUM (L.) Sw. Virginia Grape-fern. Rather more common than B. obliquum and occurring in similar situations.

OSMUNDA SPECTABILIS WILLD. Royal Fern. (Distinct from O. regalis L. of Europe). Common along small streams.

OSMUNDA CINNAMOMEA L. Cinnamon Fern. Common along small streams and in low, damp places.

POLYPODIUM VULGARE L. Common Polypody. Very rare. Known only to occur at Upper Laurel Hill where it covers the face of a high rock, looking north.

*Geological and Natural History Survey of North Carolina, Part III, Raleigh, 1867.

POLYPODIUM POLYPODIOIDES (L.) A. S. Hitchcock. (P. incanum Sw.). Resurrection Fern. On shaded trunks of elms and occasionally on rocks; not rare.

PTERIDIUM AQUILINUM (L.) Kuhn. (Pteris aquilina L.) Bracken or Brake. In dry woods and sometimes in fields. Common.

ADIANTUM PEDATUM L. Maiden-hair Fern. Found in three situations; in rich places near the foot of hills looking north.

CHEILANTHES LANOSA (Michx.) Watt. (C. vestita Sw.) Hairy Lip-fern. Found only on one rock on northern side of Morgan's Creek near Scott's Hole.

ASPLENIUM PLATYNEURON (L.) Oaks. (A. ebeneum Ait.) Ebony Spleenwort. Common in woods and in niches of stone walls.

ASPLENIUM ACROSTICHOIDES Sw. Silvery Spleenwort. Found only in two clumps near the base of Lone Pine Hill looking north.

ASPLENIUM FELIX-FOEMINA (L.) Bernh. Lady Fern. Very common along streams and in damp places.

WOODWARDIA AREOLATA (L.) Moore. Chain Fern. Found only in a marshy spot about one-half mile south-west of the University.

ONOCLEA SENSIBILIS L. Sensitive Fern. Scattered here and there in wet places.

DRYOPTERIS ACROSTICHOIDES (Michx.) Kuntze. Christmas Fern. Abundant along streams and on northern slopes of hills.

DRYOPTERIS THELYTERIS (L.) A. Gray. Marsh Shield-fern. Found only in marsh north of Lone Pine Hill.

DRYOPTERIS GOLDIEANA (Hook.) A. Gray. var. celsa. This fern was recently found near the northern foot of Lone Pine Hill. About eight specimens occurred scattered over a radius of seventy-five yards. It has not before been recorded for this State. It was described from Dismal Swamp by Palmer in the Proceedings of the Biological Society of Washington, Volume XIII, page 65, 1899. Specimens have since

been found in New York and New Jersey. For this information I am indebted to Professor L. M. Underwood and Mr. R. C. Benedict of New York. Dr. Underwood considers the fern a hybrid between D. goldieana and D. marginalis. It is not described in any of our manuals.

PHEGOPTERIS HEXAGONOPTERA (Michx.) Fée. Beech Fern. Not uncommon in flat places along small streams.

WOODSIA OBTUSA (Spreng) Torr. Found only on a few stone walls in town.

The fern allies found here are as follows:

EQUISETUM HYEMALE L. Scouring-rush. Found by Dr. H. V. Wilson along Morgan's Creek. Occurring also along the Oxford road near Durham.

LYCOPODIUM ALOPECUROIDES L. Club-moss. Growing only in an open wet place near the spot where Woodwardia was found.

LYCOPODIUM COMPLANATUM L. Christmas-green. Found by me only near upper Laurel Hill. Reported from a few places by others.

SELAGINELLA APUS L. Spring. Rather common among moss in wet places.

SALISBURY'S PHYSIOGRAPHY.*

COLLIER COBB.

Teachers of physiography in colleges will welcome this book, not only because it is the first of its kind of college grade, but also for the large amount of fresh material that it contains and its admirable arrangement, the author being at the same time a skilled investigator and a successful teacher.

"In the preparation of the text," he tells us, "the effort has been to shape it, when practicable, so as to lead the student into the subject under discussion, rather than to tell him the conclusions which have been reached by those who have made the subject their special study." The author holds persistently to that idea of physiography which regards the origin of land forms as its chief problem. This is not the English idea of physiography, but it is preëminently the American idea. It is the geography which Mackinder of Oxford defined as the study of the present in the light of the past, as distinguished from geology, which is the study of the past in the light of the present.

If the high school teacher is disappointed that small space has been given to certain topics that he has associated with text-books of physical geography, such as minerals and rocks, and plants and animals, let him remember that in colleges, where the author purposes the book shall be used, special courses in these related subjects are given in associated departments. In fact a strong point of the book is that,

*PHYSIOGRAPHY. By Prof. R. D. Salisbury, University of Chicago. 8 vo. 770 pp. American Science Series—Advanced Course. $3.50. New York: Henry Holt and Company.

with the exception of a few references to physiographic effects on human life, scattered through its pages, it presents physiography as a science associating causes and effects clearly and forcibly, thus avoiding the mistake made by many who exalt physiographic control at the expense of a science deeply interesting for its own sake.

Any study of the origin of land forms involves the study of both air and water, since air is the medium through which solar energy is applied to the earth, and water is the greatest agent in producing effects on the earth's surface. Though the greater part of the book is given to land forms, still 273 pages remain for the treatment of the atmosphere, the ocean, and the earth's solar relations. The treatment is essentially dynamic, and the movement in the direction of the explanation of the origin of the land forms of the earth. The reader is led to see these forms in the process of becoming what they are, and to anticipate the time when they shall give way to other forms. The surface of the earth becomes a stage where physical forces play their part, now in one role, now in another, until the land above the sea is reduced to base level, or rejuvenated by elevation to begin a similar sequence of events, to enter upon a new cycle.

The first chapter of the book introduces the reader to the chief relief forms of the earth's crust and the materials out of which they are made. This general survey places the problem of the land forms well before the student, and prepares him for the consideration of the agents that have shaped them. Then follow chapters explaining and discussing the work of the atmosphere, of ground water, running water, snow and ice, of waves and currents in the construction of shore forms, of vulcanism, and the effects of crustal movement, or diastrophism. For the first time does the work of the atmosphere receive anything like adequate treatment in a text-book of physiography. These chapters are followed by a very excellent generalization and summary of the origin and distribution of land forms clinching in the minds of the students the facts that have been brought out and driven home by varied investigations.

The part played by the atmosphere in the evolution of surface forms has received a treatment comparable in detail to that presented by special text-books of meteorology. The energy derived from the sun is followed through a series of transformations, in the chapters on atmospheric pressure, the movement of air currents, and the transportation of water vapor to its final precipitation upon the earth. The various elements of climate and the zones of climate receive due attention. In these chapters the composition of the atmosphere, the air in its life relations, the distribution of temperatures over the earth, and the philosophy of the movements of the air are treated in an interesting and original manner. The chapter on the storms of the United States is especially detailed and illustrated by a complete series of isothermal charts and weather maps. Following the chapters on the atmosphere, six chapters covering fifty pages are given to the discussion of the principal facts of oceanography.

The book contains more than seven hundred illustrations, forty-three of which are sections of topographic maps; and of the others more than half are half-tones from excellent photographs. This can by no means replace field-work but serves rather to invite to work out of doors; for the author says in his preface: "Another phase of work which should not be neglected is work out of doors. This must form a part of the work of every strong course in this subject. Directions for local field-work cannot be outlined profitably in a text-book, for the work must be shaped with reference to the specific locality where the subject is studied. Both field-work and map work should have for their aim the application of the principles studied, in such a way as to make the subject vital. The aim of every laboratory exercise carried out in connection with this subject should be the same, and any laboratory work which does not either illustrate and enforce principles, or lead to them, is not worth development. The student who cannot apply what he has learned in the class-room to to his out-of-door surroundings, has not secured the maximum good from his study of the subject."

At the end of each chapter is a well selected list of topographic maps, with suggestions as to their use in relation to the text, and a list of classified and paged references for supplementary reading. These references, even without the text, would be a most valuable aid to the advanced student or teacher, as they have been gathered through long experience in the class room. The author's style is pleasing and not too technical, and the average public school teacher will find the book an invaluable aid in the teaching of physical geography, though it was written primarily for the college student.

JOURNAL

OF THE

Elisha Mitchell Scientific Society

DECEMBER, 1907

VOL. XXIII NO. 4

ARTIFICIAL KEY TO THE SPECIES OF SNAKES AND LIZARDS WHICH ARE FOUND IN NORTH CAROLINA.

1. Eyelids moveable; external ear present; underparts covered with numerous scales; limbs present, except in Ophisaurus. *Lizards.* 2.
   Eyelids immovable, no external ears; underparts covered with broad band like plates; limbs absent. *Snakes.* 7.

2. Limbs absent. Length when adult about 2 ft. of which about two thirds are normally tail. **Glass or Joint Snake.* (*Ophisaurus ventralis*).
   Limbs present. Length when adult 1 ft. or less. 3.

3. Body very smooth and shiny. 4.
   Body not very smooth and shiny, scales at least somewhat rough. 5.

4. Length about 5 inches or less, unstriped. *Ground Lizard* (*Leiolepisma laterale*).
   Length over 5 inches or else with lengthwise stripes. Large adults often unstriped with reddish head. *Blue-*

*The tail as in all lizards is very easy to break off, and hence a glass snake with an injured tail growing afresh, may have the tail quite short.

tailed Lizard, "*Red-headed Scorpion*" (*Eumeces quinquelineatus.*)

5. Back crossbanded, or else throat and sides of belly dark blue. Scales very rough. *Fence Lizard* (*Sceloporus undulatus*).
Back not crossbanded, throat not dark blue, scales not very rough. 6.

6. Back with lengthwise stripes *Sand Swift* (*Cnemidophorus sexlineatus*).
Back unstriped. Color green, brown or blackish. *Green Lizard*, "*Chameleon*" (*Anolis carolinensis*).

7. A pit of hollow in the side of head between eye and nostril. Plates on underside of tail mostly not in pairs. Head much broader than the neck. *The Rattlesnakes and their kin.* (*Family Crotalidae*). 8.
No pit on side of head between eye and nostril. Plates on under side of tail in pairs. Top of head covered with large plates. 11.

8. Tail with a rattle. Top of head covered with large plates. Size small. Rattle small. *Ground Rattlesnake* (*Sistrurus miliarius*).
Tail with a rattle. Top of head covered with small scales. Size large, rattle large. 9.
Tail without a rattle. Top of head covered with large plates. 10.

9. Markings on back in form of diamond-shaped blotches. *Diamond Rattlesnake* (*Crotalus adamanteus*).
Markings on back in form of dark, ragged-edged cross bands, or sometimes when the animal is very dark, wholly absent. *Banded Rattlesnake* (*Crotalus horridus*).

10. Top of head blackish brown, colors darker. **Cottonmouth* (*Ancistrodon piscivorus*).

* The Cottonmouth is continually confused with the large water snakes of the genus Natrix, which are perfectly harmless.

Top of head reddish, colors paler. *Copperhead* (*Ancistron contortrix*).

11. Upper parts unmarked. 12.
Upperparts with evident markings. 22.

12. Upper parts green. 13.
Upper parts not green. 14.

13. †Scales keeled. *Southern Green Snake* (*Cyclophis aestivus*).
Scales smooth. *Northern Green Snake* (*Liopeltis vernalis*).

14. Color of upper parts black. 15.
Color of upper parts some shade of brown. 17.

15. Snout recurved and keeled. Scales keeled. *Black Adder* (*Heterodon platyrhinus var. niger*).
Snout as usual, not recurved nor keeled. 16.

16. Scales all smooth. Underparts slaty black except the throat which is white. *Black Snake* (*Bascanion constrictor*).
Middle rows of scales faintly keeled. Underparts blackish, except for about the front third, which is white. *Chicken Snake* (*Coluber obsoletus*).

17. Scales keeled. 18.
Scales smooth. 19.

18. Size small, under 1 ft. when adult. *Brown Snake* (*Haldea striatula*).
Size large. Coppery red below. *Copperbelly* (*Natrix f. erythrogastra*).

19. Size large. (Young crossbanded, a foot long when hatched.) *Coachwhip* (*Bascanion flagellum*).
Size small, under one foot when adult. 20.

† The scales of a snake are either perfectly smooth or else with a little ridge down the middle, in the latter case they are said to be keeled.

20. Under parts reddish. *Ground Snake* (*Carphophiops amoenus*).
Under parts whitish or yellowish. 21.

21. Top of head darker than back. Color of back reddish brown. *Brown-headed Snake* (*Rhadinaea flavilata*).
Top of head same color as back. Color of upper parts grayish brown. **Valerias Snake* (*Virginia valeriae*).

22. Markings confined to red and black blotches on the sides. Under parts red. Size large, scales smooth. *Horn Snake* (*Farancia abacura*).
Markings on upper parts confined to a light or dark cross band on neck. 23.
Back striped or spotted or both. 24.

23. Under parts white, crossband on neck black. *Crowned Tantilla* (*Tantilla coronata*).
Under parts reddish, crossband on neck white. *Brown Snake* (*Haldea striatula*), *some young specimens.*
Under parts yellow, spotted with black, crossband on neck, yellow. *Ringnecked Snake* (*Diadophis punctatus*).

24. Body striped lengthwise. 25.
Body not striped lengthwise. 31.

25. Scales keeled. 26.
Scales, or at least most of the lower rows, smooth. 30.

26. Under parts with dark stripes. *Willow Snake* (*Natrix leberis*).
Under parts not striped. 27.

27. Size small, under 1 ft. when adult. No side stripes but only one down the middle of back. 28.
Size larger, adults over two feet in length. Side stripes usually present. 29.

28. Under parts red. Three pale spots on nape. *Redbellied Snake* (*Storeria occipitomaculata*).

*Valerias Snake usually has small blackish dots on back, but these are not very conspicuous.

Under parts whitish. Not three pale spots on nape. *DeKays Snake* (*Storeria dekayi*).

29. Side stripes on third and fourth rows of scales, counting from belly plates; no square black spots between stripes of side and that on back. *Slim Garter Snake* (*Eutaenia sirtalis*).
Side stripes on second and third rows of scales. Square black spots between stripes. *Garter Snake* (*Eutaenia sirtalis*).

30. Three red stripes on a darker ground. Underparts red, spotted with black. *Hoop Snake* (*Abastor erythrogrammus*).
Four dark stripes on a lighter ground. Underparts yellowish. *Striped Chicken Snake* (*Coluber quadrivittatus*).

31. Body above with crossbands of red, black, and white (or yellow). 32.
Body not colored as above. 34.

32. Every alternate crossbar yellow. *Coral Adder* (*Elaps fulvius*).
Every alternate crossbar black. 33.

33. Snout narrow, under parts white. *Red Snake* (*Cemophora coccinea*).
Snout rounded, under parts with black markings. *Red King Snake* (*Ophibolus doliatus coccineus*).

34. Scales all smooth. 35.
Scales keeled. 42.

35. Black with narrow white crossbars forking on the sides. *King Snake* (*Ophibolus getulus*).
Not as above. 36.

36. Underparts with squarish black spots. 37.
Underparts not with squarish black spots. 38.

37. Head large, broader than the neck. †Anal plate divided. *Spotted Racer. Rat Snake* (*Coluber guttatus*).
Head small, not broader than neck. Anal plate undivided. *Milk Snake* (*Ophibolus doliatus triangulus*).

38. Head large, broader than neck. Anal plate divided. 39.
Head small, not broader than neck. Anal undivided. *Brown King Snake* (*Ophibolus rhombomaculatus*).

39. ‡Scales in 25 or 27 rows. 40.
Scales in 19 rows. 41.

40. Underparts yellowish. *Striped Chicken Snake, young.*
Underparts slaty black behind, whitish in front. *Chicken Snake, young.*

41. §Upper lip plates 7 on each side. *Black Snake, young.*
Upper lip plates 8 on each side. *Coachwhip, young.*

42. Snout recurved and keeled. 43.
Snout not recurved and keeled. 44.

43. Small plate just behind snout plate with several small scales round it. Snout more strongly recurved and keeled. *Hognosed Snake* (*Heterodon simus*).
Small plate just behind snout plate without any small scales round it. Snout less strongly keeled and recurved. *Spreading Adder* (*H. platyrhinus*).

44. Anal plate undivided. Ground color whitish with dark spots on back. *Bull Snake* (*Pityophis melanoleucugs*).
Anal plate divided. 45.

†Anal plate is the plate immediately in front of the vent, which in most of our forms is divided longitudinally into two pieces, but in some it is undivided.

‡Rows of scales are counted diagonally beginning with the row just above the belly plates and are usually uneven in number.

§The upper labials or lip plates are the plates along the edge of the upper lips, excluding the plate at tip of snout.

45. Only the middle rows of scales keeled, size small. **Chicken Snake, young*.

All rows of scales strongly keeled. 46.

46. Spots on back forming crossbars with no alternating spots on sides. *Southern Water Snake* (*Natrix fasciata fasciata*).

Spots on back forming crossbars on front part of body, and on hinder part alternating with spots on the sides. *Common Water Snake* (*Natrix fasciata Sipedon*).

Spots on back alternating with spots on sides from head to tail. *Pied Water Snake* (*Natrix taxispilota*).

NOTES ON THE SPECIES INCLUDED IN THE KEY.

The following species are poisonous: The three species of Rattlesnake (Ground, Banded, and Diamond Rattlesnakes), the Copperhead, and the Cottonmouth, and lastly the Coral Adder, which last belongs to the same group of snakes as the deadly cobra of India. The following harmless snakes are often confused with poisonous species: the Spreading Adder with the Copperhead; the harmless water snakes with the cottonmouth, both forms being indiscriminately known as water moccasins; and thé red snake and red king snake with the coral adder.

A few of the species listed have not yet been recorded from North Carolina, these are the coral adder, northern green snake, coachwhip, and milk snake, and we have only one unsatisfactory record of the bull snake.

Of the species included in the key, the following have not yet been taken in this state outside of the lower austral life zone, whose northern boundary in this state appears to be approximately a line drawn from Norfolk through Raleigh, and thence to Charlotte:

*The Southern Chicken Snake (Coluber obsoletus confinis) may possibly occur, in which case the keys for the young of the Chicken Snake would apply to this also. I do not know how the young of the two forms would be distinguished.

Glass Snake, at Raleigh, Garner, Southport, Beaufort.

Green Lizard, at Southport, Wilmington, Beaufort, Lake Ellis, Tryon, and Lumberton.

Hoop Snake, at Newberne, Kinston, Wilmington, Lake Ellis.

Horn Snake, at Newberne, Wilmington, Lake Ellis.

Brown headed Snake at Fort Macon.

Hognosed Snake in Wake Co., at Goldsboro and Lake Ellis.

Spotted Racer at Raleigh, Lake Ellis and Washington.

Striped Chicken Snake, at Newberne and Cape Hatteras.

Red King Snake, at Raleigh.

Red Snake at Raleigh.

Pied Water Snake at Kinston, Avoca, Newberne and Lake Ellis.

Southern Water Snake at Newberne, Wilmington, and Lake Ellis.

Crowned Tantilla at Raleigh.

Cottonmouth at Newberne, Wilmington, Lake Ellis, Cape Hatteras, Beaufort, Washington, and Raleigh.

Ground Rattlesnake, at Wilmington, and Beaufort.

Diamond Rattlesnake at Havelock below Newberne.

Records of the Coral Adder, Coachwhip, Milk Snake, Northern Green Snake, and Bull Snake are very much desired as also records of any other species of snakes and lizards, particularly those confined to the lower austral zone.

Of the four species listed as possibly occurring in the state, the Coral Adder and Coachwhip are confined to the lower austral zone, and should be looked for in the southeastern portion of the state, while the Milk Snake is most apt to be found in the northwest corner. The Northern Green Snake is apt to occur anywhere in the state but is not likely to be common anywhere, and the Bull Snake, of which we have a doubtful record from Wake Co. is liable to occur in the pine woods of the region near the coast.

The other species of snakes and lizards probably occur throughout the entire state, except in portions of the moun-

tain region, but our actual records are few and scattered.

Persons having specimens of any reptile that they are not well acquainted with, would do well to communicate with the Curator of the State Museum at Raleigh, or with myself.

C. S. BRIMLEY,
Newberne Ave., cor. Tarboro St.,
Raleigh, N. C.

(Information is also desired concerning the occurrence of the alligator in the state and also as to the occurrence of the species of soft shelled turtles in the Mississippi drainage as well as in the southeast of the state, the two different parts in which they may possibly occur.)

THE SALAMANDERS OF NORTH CAROLINA

C. S. BRIMLEY

Salamanders are animals which are commonly confused with lizards and which mainly resemble them in external appearance. Their true affinities, in spite of the possession of limbs, are however with the fishes, with which group they and the other amphibians are sometimes combined under the name of Icthyopsida.

They differ externally from from all our lizards in the possession of a moist skin without scales, while all our lizards have a dry scaly skin. The skin in salamanders and other amphibians (frogs and toads) is always moist, and used to some extent (wholly in many species) as an organ of respiration.

The forms which occur or are liable to occur in this state may be recognized by the following key.

KEY TO THE SALAMANDERS OCCURING OR LIABLE TO OCCUR IN NORTH CAROLINA

1. Adults with with external gills, 2.
   Adults without external gills, 5.
2. Hind limbs absent, 3.
   Hind limbs present. Toes 4 on both hind and fore-feet, 4.
3. Toes 4. Size large. *Great Siren* (*Siren lacertina*).
   Toes 3. Size small. *Little Siren* (*Pseudobranchus striatus*).
4. Brown with darker spots. Water Dog (*Necturus maculatus*).

Pale unspotted. *Southern Water Dog* (*Necturus punctatus*).

5. Adults with a rounded opening on each side of neck, 6.
Adults without a rounded opening on each side of neck, 7.

6. Body eel-shaped, with rudimentary limbs. Toes 2 or 3 each on both fore and hind feet. *Ditch Eel* (*Amphiuma means*).
Body stout, salamander shaped. Toes 4 on fore, 5 on hind feet. *Hellbender* (*Cryptobranchus alleghaniensis*).

7. Tongue mushroom shaped, i. e. a circular disk on a central stalk, 8.
Tongue not attached by a central stalk only, 15.

8. Toes on hind feet 4. Size very small, yellowish brown. *Dwarf Salamander* (*Manculus quadridigitatus*).
Toes on hind feet 5. (Genus Spelerpes), 9.

9. *Costal grooves, 13 or 14. 10.
Costal grooves 15 to 17. 13.

10. Tail about as long as rest of body. Yellow with a dark line along each side of back. Underparts unmarked. *Striped Salamander* (*S. bilineatus*).
Tail 1 1–2 to 2 times as long as body. 11.

11. Color vermilion red, with many brown spots. Tail spotted, not barred. *Spotted tailed Trition* (*S. maculicaudus*).
Color yellow. 12.

12. Underparts marbled with black. Back with a black stripe down middle and another on each side. *Holbrook's Triton* (*S. guttolineatus*).
Underparts unmarked. Back and sides with irregular black spots. *Long-tailed Salamander* (*S. longicauda*).

*Costal grooves are grooves on the sides indicating where the ribs are.

13. *Upper jaw bearing on its margin, immediately below each nostril, a prominent tubercule. Color light chocolate brown, spotted with brown. Underparts unmarked. *Daniel's Salamander* (*S. danielsi*).
Upper jaw bearing no such tubercle. 14.

14. Color red of varying shades spotted above or below with black or both. *Red Triton* (*S. ruber*).
Color yellowish or purplish brown above, irregularly blotched with gray. *Purple Salamander* (*S. porphyriticus*).

15. Head with three longitudinal grooves. Underparts yellow or red below with black dots. 16.
Head without longitudinal grooves. 17.

16. Each side with a row of red spots, each spot surrounded by a black ring. *American Newt* (*Diemyctylus viridescens*).
Each side with a series of black bordered red lines, replacing the black ringed spots. *Wilmington Newt* (*D. v. vittatus*).

17. Salamanders with rather long toes on all four feet, the outer and inner ones well developed. Tail compressed. (Genus Ambystoma). 18.
Salamanders with shorter toes, the outer or inner toes or both usually reduced in size or rudimentary. Tail not much compressed. 26.

18. Costal grooves 10. Form short and stout. Color blackish brown with gray, lichen like markings. *Mole Salamander* (*A. talpoideum*).
Costal grooves more than 10. 19.

19. Costal grooves usually 11. 20.
Costal grooves 14. 23.

*Similar tubercles occur more or less frequently in Manculus quadridigitaus, Sp. bilineatus, Sp. guttolineatus and regularly in Sp. maculicauda.

20. Bluish black with gray or white blotches or crossbars on the upper parts of head, body and tail, usually about 12 or 14 in all. Underparts unmarked. *Marbled Salamander* (*A. opacum*).
Not as above. 21.

21. Black with a series of large round yellow spots down each side of back. A strong dorsal groove. *Spotted Salamander* (*A. punctatum*).
Lead colored with one or two series of small yellow spots along sides. No dorsal groove, size small. *Smaller Spotted Salamander* (*A. conspersum*).
Not as above. 22.

22. Dark brown, yellowish below. No markings. *Sope's Salamander* (*A. Sopeanum*).
Olive brown, yellowish below. Limbs banded, tail spotted. A few ill-defined yellowish spots above. *Two colored Salamander* (*A. bicolor*).

23. Markings grayish or whitish. 24.
Markings brown or yellow. 25.

24. Olive brown or blackish with pale or bluish spots, these sometimes absent. *Jefferson's Salamander* (*A. jeffersonianum*).
Black with a narrow gray line between each pair of costal folds, these either crossing the back undivided to meet their fellows from the opposite side or forking to meet a similiar fork from the other side. Underparts thickly speckled with gray. *Banded Salamander* (*A. cingulatus*).

25. Tail very long, much longer than head and body. *Ohio Salamander* (*A. xiphias*).
Tail about as long as head and body. Color varying from uniform brown to yellow, but usually spotted. *Tiger Salamander* (*A. tigrinum*).

26. Toes on hind feet 4. Underparts with dots like ink spots. *Scaly Salamander* (*Hemidactylium scutatum*).
Toes on hind feet 5. 27.

27. Head with enlarged pores, which give it a pitted appearance. Underparts usually with black dots. Sides with dark longitudinal stripes. *Margined Salamander* (*Stereochilus marginatus*).
Not as above. 28.

28. Tail compressed and finned at least for the apical two thirds. 29.
Tail rounded. 32.

29. Color wholly black above and below. *Black Triton* (*Desmognathus nigra*).
Color not all black. 30.

30. Snout very flat, broad and depressed. Yellowish buff, thickly marked above with confluent black blotches. Underparts unmarked. *Moore's Triton* (*Leurognathus marmoratus*).
Snout more or less arched. 31.

31. Skin of head granulated. Underparts usually more or less uniform slate color. Size rather large. *Mountain Triton* (*Desmognathus quadrimaculatus*).
Skin of head not granulated. Underparts pale. *Brown Triton* (*Desmognathus fusca*).

32. Color brownish yellow, often spotted. *Yellow Salamander* (*Desmognathus ochrophea*).*
Color blackish or plumbeous. (Genus Plethodon.) 33.

33. Color lead-colored with a chestnut red dorsal band, size small. *Redbacked Salamander* (*P. erythronotus*).
Color uniform lead color. *Plumbeous Salamander P. e. cinereus*).
Color black with various markings. 34.

34. Black with red legs. *Sherman Salamander* (*P. Shermani*).

*All the species of the the genus Desmognathus have a peculiar physiognomy which is very characteristic, but not easy to describe.

Black with an orange yellow stripe on sides of head and neck. *Jordan Salamander* (*P. jordani*).

Black with bluish white blotches and specks, occasionaly unspotted. *Slimy Salamander* (*P. glutinosus*).

Black with yellowish green blotches of irregular form on back and sides. *Bronzy Salamander* (*P. aeneus*).

Of the above species the following have not yet been taken in the state: Little Siren, Spotted-tailed Triton, Long-tailed Salamander, Smaller spotted Salamander, Cope's Salamander Two-colored Salamander, Banded Salamander, Ohio Salamander, Scaly Salamander, Jordan Salamander, Bronze Salamander. Most of these however may possibly occur, and some of them are almost certain to be secured with more careful and complete collecting.

The species known to occur in the State have been collected in the following localities:

Great Siren. Craven Co., New Hanover Co.

Water Dog. Wake.

Southern Water Dog. New Hanover.

Ditch Eel. Wake, Edgecombe, Dare, Bertie and Craven.

Hellbender. Yancey.

Dwarf Salamander. Wake, Lenoir.

Striped Salamander. Wake, Buncombe, Yancey, Mitchell and Forsyth.

Holbrook's Triton. Wake, Buncombe, Forsyth, and valley of French Broad.

Daniel's Salamander. Yancey.

Red Triton. Wake, Buncombe, Mitchell, Carteret, Yancey, Burke, Orange, Wayne, Forsyth and Henderson.

Purple Salamander. Mitchell.

American Newt. Wake, Henderson, Lenoir.

Wilmington Newt. New Hanover.

Mole Salamander. Valley of French Broad.

Marbled Salamander. Wake, Edgecombe, Guilford, Columbus, Forsyth, Lenoir.

Spotted Salamander. Wake.

Tiger Salamander. Moore.

Jefferson Salamander. Mitchell.

Redbacked Salamander. Mitchell, Pitt (same localities for Plumbeous S).

Margined Salamander. Craven.

Black Triton. Mitchell.

Moore's Salamander. Grandfather Mt.

Mountain Salamander. Yancey, Mitchell, Henderson.

Brown Triton. Wake, Craven, Forsyth, Lenoir.

Yellow Triton. Yancey, Mitchell.

Sherman Salamander. Nantahala Mt.

Slimy Salamander. Whole State.

A KEY TO THE SPECIES OF FROGS AND TOADS LIABLE TO OCCUR IN NORTH CAROLINA

C. S. BRIMLEY

1. Upper jaw without any teeth. 2.
   Upper jaw with teeth. 5.

2. Skin smooth. Size small. Snout pointed. No paratoid glands (just behind ear). Hind feet not webbed. *Toothless Frog* (*Engystoma carolinense*).
   Skin warty. Paratoids large. Hind feet little webbed. Head with bony ridges above. Toads. 3.

3. Size small, length of head and body one inch. Skin very rough. Bony ridges turning inward almost at right angles just back of the eyes. *Dwarf Toad* (*Bufo quercicus*).
   Size larger, adults about 3 or 4 inches long. Skin not so rough. Bony ridges on top of head not turning abruptly inward back of eyes. 4.

4. Bony ridges ending in a knob behind. *Southern Toad* (*B. lentiginosus*).
   Bony ridges not ending in a knob behind. *Common Toad* (*B. l. americanus*).

5. Paratoids present. Hind feet webbed. Heel with a flat, sharp-edged spur. *Solitary Spadefoot Scaphiopus holbrooki*).
   Paratoids absent. No sharp edged spur on heel. 6.

6. Fingers and toes dilated at their tips, this dilation forming a viscous disk. Tree frogs. 7.
   Fingers and toes not much dilated at tips. 13.

7. Back with a dark x-shaped mark, size small. *Peeper* (*Hyla pickeringi*).
Back marked or not, but if marked, the markings do not form an x-shaped mark. 8.

8. Back of thigh not marked with yellow spots or variegations. 9.
Back of thigh with yellow spots or variegations. 11.

9. A yellow band on upper lip and sides of body, sharply defined above and below. Back with minute yellowish spots. *Carolina Tree Frog* (*Hyla cinerea*).
Yellow or white band on sides not sharply defined above and below. 10.

10. Size large, feet edged with yellow. *Georgia Tree Frog* (*H. gratiosa*).
Size small, feet not edged with yellow. *Squirrel Tree Frog* (*H. squirella*).

11. Size large, skin of back rough. A light spot on upper jaw just below eye. *Common Tree Frog* (*H. versicolor*).
No light spot below eye. 12.

12. A plum colored line along sides of body with yellow spots below it. *Anderson's Tree Frog* (*H. andersoni*).
No yellow spots on sides. *Pine woods Tree Frog* (*H. femoralis*).

13. Feet unwebbed, size small. (Genus Chorophilus). 14.
Feet more or less webbed. 15.

14. Skin of upper surface granulated. *Chorus Frog* (*C. nigritus and subspecies*).
Skin of upper surface smooth, a dark patch on ear. *Smooth Chorus Frog* (*C. occidentalis*).

15. Size small. Skin above warty. A dark triangle between eyes. *Cricket Frog* (*Acris gryllus*).
Size larger. Skin above smooth. 16.

16. A ridge of raised skin along each side of back. 17.
No narrow ridge of raised skin along side of back. 19.

17. A black ear patch. *Wood Frog* (*Rana sylvatica*).
    No black ear patch. 18.
18. Fold of skin down each side of back white. Back with large dark spots. *Leopard Frog* (*Rana pipiens*).
    Fold of skin down each side of back the same color as back. Back with a few small dark spots or none. *Spring Frog* (*Rana clamata*).
19. Back with large dark spots in two rows. Size medium. *Pickerel Frog* (*Rana palustris*).
    Back with irregular dark spots or none. Size large. *Bullfrog* (*Rana catesbiana*).
    Sides with two light brown longitudinal bands. *Cope's Frog* (*Rana virgatipes*).

Of the species included in the key the following have not yet to my knowledge been recorded from from North Carolina: Anderson's Tree Frog, Georgia Tree Frog, Smooth Chorus Frog, and Southern Toad.

The other species have been taken in the following localities:

Toothless Frog. Wake, Johnston and Wayne Co's.

Dwarf Toad. Lenoir and Carteret.

Common Toad. Forsyth, Wake, Jackson, Craven, Lenoir and Wayne.

Solitary Spadefoot. Wake.

Peeper. Wake, Mitchell, Wayne, Johnston, Guilford.

Carolina Tree Frog. Lenoir and Dare.

Squirrel Tree Frog. Dare, Craven, Brunswick.

Pine woods Tree Frog. Craven and New Hanover.

Common Tree Frog. Wake, Wayne, Forsyth Pitt.

Chorus Frog. Guilford and Wake.

Cricket Frog. Wake, Craven, Wayne, Forsyth, Guilford.

Wood Frog. Lenoir.

Pickerel Frog. Wake, Mitchell, Lenoir.

Leopard Frog. Wake, Craven, Edgecombe, Dare.

Spring Frog. Craven, Wake, Forsyth, Guilford, Mitchell.

Bullfrog. Wake, Craven, Edgecombe.

Cope's Frog. Craven.

These keys (to snakes and lizards, salamanders, and to toads and frogs) have been prepared with the idea of giving intelligent persons without special knowledge on the subject an opportunity of identifying our native forms of these groups. The keys must not be expected to be infallible though I have endeavored to make them as accurate as possible.

ON SOME PHENOMENA OF COALESCENCE AND REGENERATION IN SPONGES[1]

BY H. V. WILSON

I

In a recent communication I described some degenerative and regenerative phenomena in sponges and pointed out that a knowledge of these powers made it possible for us to grow sponges in a new way. The gist of the matter is that silicious sponges when kept in confinement under proper conditions degenerate in such a manner that while the bulk of the sponge dies, the cells in certain regions become aggregated to form lumps of undifferentiated tissue. Such lumps or plasmodial masses, which may be exceedingly abundant, are often of a rounded shape resembling gemmules, more especially the simpler gemmules of marine sponges (Chalina, *e. g.*), and were shown to possess in at least one form (Stylotella) full regenerative power. When isolated they grow and differentiate, producing perfect sponges. I described moreover a simple method by which plasmodial masses of the same appearance could be directly produced (in Microciona). The sponge was kept in aquarium until the degenerative process had begun. It was then teased with needles so as to liberate cells and cell agglomerates. These were brought together with the result that they fused and formed masses similar in appearance to those produced in this species when the sponge remains quietly in aquarium. At the time I was forced to

1Reprinted from JOURNAL OF EXPERIMENTAL ZOÖLOGY, VOL. V, NO. 2., and published with the permission of Hon. Geo. M. Bowers, U. S. Commissioner of Fisheries.

leave it an open question whether the masses of teased tissue were able to regenerate the sponge body.

During the past summer's work at the Beaufort Laboratory[2] I again took up this question and am now in a position to state that the dissociated cells of silicious sponges after removal from the body will combine to form syncytial masses that have power to differentiate into new sponges. In Microciona, the form especially worked on, nothing is easier than to obtain by this method hundreds of young sponges with well developed canal system and flagellated chambers. How hardy sponges produced in this artificial way are and how perfectly they will differentiate the characteristic skeleton, are questions that must be left for more prolonged experimentation.

Taking up the matter where it had been left at the end of the preceding summer, I soon found that it was not necessary to allow the sponge to pass into a degenerative state, but that the fresh and normal sponge could be used from which to obtain the teased out cells. Again in order to get the cells in quantity and yet as free as possible from bits of the parent skeleton, I devised a substitute for the teasing method. The method adopted is rough but effective.

Let me briefly describe the facts for Microciona. This species (M. prolifera Verr.) in the younger state is incrusting. As it grows older it throws up lobes and this may go so far that the habitus becomes bushy. The skeletal framework consists of strong horny fibers with embedded spicules. Lobes of the sponge are cut into small pieces with scissors and then strained through fine bolting cloth such as is used for tow nets. A square piece of cloth is folded like a bag around the bits of sponge and is immersed in a saucer of filtered sea-water. While the bag is kept closed with the fingers of one hand it is squeezed between the arms of a small pair of forceps. The pressure and the elastic recoil of the

2I am indebted to the director of the station, Mr. H. D. Aller, for his kindly aid in supplying all facilities needed in the course of my investigation.

skeleton break up the living tissue of the sponge into its constituent cells, and these pass out through the pores of the bolting cloth into the surrounding water. The cells, which pass out in such quantity as to present the appearance of red clouds, quickly settle down over the bottom of the saucer like a fine sediment. Enough tissue is squeezed out to cover the bottom well. The cells display amœboid activities and attach to the substratum. Moreover they begin at once to fuse with one another. After allowing time for the cells to settle and attach, the water is poured off and fresh sea-water added. The tissue is freed by currents of the pipette from the bottom and is collected in the center of the saucer. Fusion between the individual cells has by this time gone on to such an extent that the tissue now exists in the shape of minute balls or cell conglomerates of a more or less rounded shape looking to the eye much like small invertebrate eggs. Microscopic examination shows that between these little masses free cells also exist, but the masses are constantly incorporating such cells. The tissue in this shape is easily handled. It may be sucked up to fill a pipette and then strewn over cover glasses, slides, bolting cloth, watch glasses, etc. The cell conglomerates which are true syncytial masses throw out pseudopodia all over the surface and neighboring conglomerates fuse together to form larger masses, some rounded, some irregular. The details of later behavior vary, being largely dependent on the amount of tissue which is deposited in a spot, and on the strength of attachment between the mass of tissue and the substratum.

Decidedly the best results are obtained when the tissue has been strewn rather sparsely on slides and covers. The syncytial masses at first compact and more or less rounded, flatten out, becoming incrusting. They continue to fuse with one another and thus the whole cover glass may come to be occupied by a single incrustation, or there may be in the end several such. If the cover glass is examined at intervals, it will be found that differentiation is gradually taking place. The dense homogeneous syncytial mass first develops at

the surface a thin membrane with underlying connective tissue (collenchyma). Flagellated chambers make their appearance in great abundance. Canals appear as isolated spaces which come to connect with one another. Short oscular tubes with terminal oscula develop as vertical projections from the flat incrustation. If the incrustation be of any size it produces several such tubes. The currents from the oscula are easily observed, and if the cover glass be mounted in an inverted position on a slide the movements of the flagella of the collar cells may be watched with a high power (Zeiss 2 mm.). This degree of differentiation is attained in the course of six or seven days when the preparations are kept in laboratory aquaria (dishes in which the water is changed answer about as well as running aquaria). Differentiation goes on more rapidly when the preparation is hung in the open harbor in a live-box (a slide preparation inclosed in a coarse wire cage is convenient). Sponges reared in this way have been kept for a couple of weeks. The currents of water passing through them are certainly active and the sponges appear to be healthy. In such a sponge spicules are present, but some of these have unquestionably been carried over from the parent body along with the squeezed out cells.

The old question of individuality may receive a word here. Microciona is one of that large class of monaxonid sponges which lack definite shape and in which the number of oscula is correlated simply with the size of the mass. While we may look on such a mass from the phylogenetic standpoint as a corm, we speak of it as an individual. Yet it is an individual of which with the stroke of a knife we can make two. Or conversely it is an individual which may be made to fuse with another, the two forming one. To such a mass the ordinary idea of the individual is not applicable. It is only a mass large or small having the characteristic organs and tissues of the species but in which the shape of the whole and the number of the organs are indefinite. As with the adult so with the lumps of regenerative tissue. They have no definiteness of shape or size, and their structure is only definite

in so far as the histological character of the syncytial mass is fixed for the species. A tiny lump may metamorphose into a sponge, or may first fuse with many such lumps, the aggregate also producing but a single sponge although a larger one. In a word we are not dealing with embryonic bodies of complicated organization but with a reproductive or regenerative tissue which we may start on its upward path of differentiation in almost any desired quantity. A striking illustration of this nature of the material is afforded by the following experiment. The tissue in the shape of tiny lumps was poured out in such wise that it formed continuous sheets about one millimeter thick. Such sheets were then cut into pieces, each about one cubic millimeter. These were hung in bolting cloth bags in an outside live-box. Some of the pieces in spite of such rough handling metamorphosed into functional sponges.

Even where the embryonic bodies of sponges have a fixed structure and size, as in the case of the ciliated larva, the potential nature as displayed in later development, is not fixed in the matter of individuality. Such a body may form a single individual or may fuse with some of its fellows to form a larger individual differing from the one-larva sponge only in size. It is then in spite of its definiteness of shape and size, essentially like a lump of regenerative tissue in that whether it develops into a whole sponge or a part of a sponge depends not on its own structure but on whether it is given a good opportunity of fusing with a similar mass. A parallel case to the coalescence of larvæ is afforded by the gemmules of fresh water sponges. Mr. M. E. Henriksen in a manuscript account submitted to me a year ago, describes the fusion of gemmules to form a single sponge.

In the preceding description I have passed over the question as to the precise nature of the cells which combine to form the masses of regenerative tissue. On this point as on the histological details in general I hope to have more to say later. Nevertheless the phenomena are so simple that observation of the living tissue reveals much, probably indeed all

that is of fundamental importance. If a fairly dense drop of the squeezed out tissue be mounted at once and examined with a high power (Zeiss 2 mm., comp. oc. 6), the preparation is seen to consist of fluid (sea-water) with a few spicules and myriads of separate cells. The cells fall into three classes.

1 The most conspicuous and abundant are spheroidal, reddish, densely granular, and about 8μ in diameter. These cells which can be nothing but the unspecialized, amœboid cells of the mesenchyme (amœbocytes or archæocytes), put out hyaline pseudopodia that are sometimes elongated, more often rounded and blunt.

2 There is also a great abundance of partially transformed collar cells, each consisting of an elongated body with slender flagellum. The cell is without the collar, the latter doubtless having been retracted. In the freshly prepared tissue the flagella are vibratile, the cells moving about. Soon however the flagellum ceases to vibrate.

3. The third class is not homogeneous. In it I include more or less spheroidal cells ranging from the size of the granular cells down to much smaller ones. Many of these are completely hyaline, while others consist of hyaline protoplasm containing one or a few granules.

Fusion of the granular cells begins immediately and in a few minutes time most of them have united to form small conglomerate masses which at the surface display both blunt and elongated pseudopodia. These masses soon begin to incorporate the neighboring collar and hyaline cells. One sees collar cells sticking fast by the end of the long flagellum to the conglomerate mass. Other collar cells are attached to the mass by short flagella. Still again only the body of the collar cell projects from the mass while there is no sign of flagellum. Similarly spheroidal hyaline cells of many sizes are found in various stages of fusion with the granular conglomerate. In such a preparation the space under the cover glass is soon occupied by innumerable masses or balls of the kind just described, between which continue to lie abundant free cells, some collar cells, others hyaline. Practically all

the granular cells go to make up the balls. The play of pseudopodia at the periphery of such balls, which results in the incorporation of free cells and in the fusion of balls to form larger masses, is easily watched. Along with such a cover glass preparation it is convenient to have some of the squeezed-out tissue in a watch glass of sea-water. In the watch glass preparation it is instructive to watch with a two-thirds or one-half objective the fusion of the cell conglomerates to form masses like those strewn on covers, slides, etc.

These observations on the early steps in the formation of the masses of regenerative tissue make it plain that such masses are composed chiefly of the spheroidal, granular cells (amœbocytes or archæocytes), but that nevertheless other cells, collar cells and more or less hyaline cells also enter into their composition. I may recall the fact that in the formation of regenerative masses in a degenerating sponge,[3] the evidence from sections, which is the only evidence available in the case, points to the conclusion that the collar cells help to form the syncytial tissue of the masses. The question of interest lying at the heart of this matter may be so formulated: can particles of the Microciona protoplasm differentiate into functional collar cells and, when the occasion arises, change back into unspecialized masses capable of combining with other masses of unspecialized protoplasm to form a regenerative body? The facts to which I have just alluded support this idea, and indicate that the immediate problem is one worth pursuing farther as a good case of temporary differentiation of protoplasm in the metazoa analogous to the temporary specialization of the cell individual which occurs in such colonial protazoa as Protospongia.[4]

As far as the amœbocytes are concerned it is certain that they have great regenerative power. Weltner in a recent

3 A new method by which sponges may be artificially reared, Science, n. s., vol. xxv, no. 649, 1907.

4 Metschnikoff, Embryologische Studien an Medusen, p. 147, 1886.

paper[5] has emphasized the importance of these unspecialized cells in the process of growth and regeneration. His conclusions which refer directly to fresh water sponges, are that in a growing sponge, in a sponge regenerating new organs after its winter period of simplification, and in the regeneration of a sponge from a cutting, the amœbocytes are the all-powerful elements in that they give rise to all the new tissues formed. He further alludes to the fact that such reproductive bodies as the gemmules of fresh water sponges and the buds of Tethya (according to Maas) are only groups of amœbocytes; further that the gemmules of Tedania and Esperella described by Wilson as developing into ciliated larvæ, and the similar bodies found by Ijima in hexactinellids, are such groups. I may add that the presence of such groups of unspecialized cells in the hexactinellids has recently been confirmed by the master in sponge-morpholagy, F. E. Schulze, who recognizes the probability of their reproductive nature and gives them a new name, that of *sorites*.[6] It is clear then that in many sponges reproductive bodies are formed by the association of unspecialized amœboid cells. But there is nothing in this fact which precludes the possibility that the groups of amœbocytes are in part recruited from transformed collar cells and other tissue cells, such as pinacocytes (flat cells of canal walls), that have undergone regressive differentiation into an unspecialized amœboid condition.

Cells analogous to the amœbocytes of sponges are found elsewhere in the metazoa, *e. g.*, in the ascidians.[7] It would be interesting to know what capacity, if any, for development they have, when freed from the parent (bud) and collected together in sea-water.

5 Spongilliden-studien V. Zur Biologie von Ephydatia fluviatilis und die Bedeutung der Amœbocyten für die Spongilliden. Archiv für Naturgeschichte, 73 Jahrg., I Bd., 2 Heft, 1907.

6 Wissensch. Ergebn. d. Deutsch. Tiefsee-Exp. 1898-99. Hexactinellida, pp. 213-15. Jena, 1904.

7 Comp. Hjort's and Lefevre's papers on budding in ascidians.

II

I shall here briefly record some experiments which gave only negative results but which under circumstances admitting of a wider choice of species, ought to yield returns of value. These experiments were based on the assumption that if the dissociated cells of a species will recombine to form a regenerative mass and eventually a new sponge, the dissociated cells of two different species may be made to combine and thus form a composite mass bearing potentially the two sets of species-characteristics. It is clear that such an organism would be analogous to one produced by an association of the blastomeres of the two species. Pending the successful carrying out of this experiment, it would be idle to discuss further the nature of the hypothetical dual organism.

In my own experiments three sponges were used: Microciona, Lissodendoryx and Stylotella. The three are all monactinellids but Microciona is the only one in which the skeleton includes any considerable amount of horny substance. Dissociated cells of Microciona and Lissodendoryx were mixed, and again dissociated cells of Microciona were mixed with those of Stylotella. In each case the experiment was performed at two different times, and a considerable number of admixtures, in watch glasses and on cover glasses, was made. The preparations were examined at short intervals with the microscope. The cells of these three species are colored very differently, and are therefore easily distinguished, at least as soon as fusion sets in and little masses of cells begin to be formed. In all the experiments the cells and cell-masses of a species combined and not the cells of different species. Thus in the admixture of Microciona and Lissodendoryx, Microciona regenerative masses and Lissodendoryx regenerative masses were produced. Similarly when Microciona and Stylotella cells were mixed, the resultant masses were pure, some Microciona, some Stylotella. The Microciona masses in these experiments were hardy. They continued to develop and in some preparations metamorphosed. The cell masses of the other two species while they reached a considerable size were

not hardy, most dying soon although some began the process of metamorphosis.

These three species are so unlike that there was little ground in the beginning for the expectation that coalescence would take place. Possibly as in the cases where fusion of egg and sperm of different species is induced through some alteration in the physiological state of protoplasm, so the generative cells and cell masses of different species may be made to combine under abnormal conditions. The more promising task is however to find allied species and subspecies, the regenerative tissue of which will combine under natural conditions. Such forms, I take it, should be sought among the horny sponges and the monactinellids with abundant horny matter.

III

The tendency to fuse so vigorously displayed by the cells and cell masses of regenerative tissue led me to examine into the power that larvæ have to fuse with one another and the capacity for development in the resultant mass. Delage and others have remarked on the not infrequent occurrence of fusion between sponge larvæ. Delage[8] says that he has often observed two or several larvæ unite to form a single sponge "which has from the start several cloacas."

I find that this power to fuse displayed by the larvæ is one that is easy to control. Fusion between the larvæ will readily take place if they are brought in contact at the critical time when the ciliated epithelium is being replaced by the permanent flat epithelium. At this time they will fuse in twos or threes or in larger number up to and over one hundred. The smaller composite masses composed of as many as five or six larvæ metamorphose into sponges. The larger masses composed of many larvæ did not metamorphose in my experiments but experience with the regenerative tissue suggests that such masses would metamorphose if certain mechanical difficulties due to the great size of the mass were

8 Embryongénie des Eponges. Arch. de Zool. Exp. et Gén., p. 400, 1892.

removed. Possibly this might be accomplished by cutting a flattened sheet composed of some hundred larvæ (such as I have produced) into pieces and inducing the pieces to metamorphose separately.

I may now describe some of the details in this process of larva-fusion. In a species of Lissodendoryx used the larva is of the following character. It has the usual ovoidal shape with a protuberant non-ciliated pole. The anterior pole is somewhat truncated and is sparsely ciliated. The rest of the body bears the usual thick covering of cilia. As seen with reflected light the bulk of the body is dead white, the posterior pole deep blue, and the anterior pole bluish. This coloration is not absolutely fixed for the species, but the larvæ used in my coalescence experiments were all of this character. Within twenty-four hours after liberation the ciliated larvæ are creeping (remaining in contact with the bottom as they swim) over the bottom of the dish. Some are now put in deep round watch glasses and with pipette and needle coaxed together into a clump. Fusion soon begins and on the next day plenty of composite larvæ are present. The larvæ fuse endwise, for the most part in pairs. The compound larva so produced owing to its weight has a very feeble locomotory power. Using pairs that are nearly motionless, larvæ may be brought together (coaxed with needle) and arranged in a desired position on a cover glass for instance. In successful cases fusion results before the separate masses move apart. In this way, selecting an instance, I have added to one arm of a quadruple mass a pair of larvæ, and to the opposite arm two pairs,

For the purpose of bringing about the fusion of many larvæ the following simple method is convenient. Suppose that we have the larvæ in a paraffine-coated dish, and they are in a late "creeping" stage. Small excavations, 2–3 mm. deep and 4–5 mm. wide, are now made in the paraffine, and with the pipette the larvæ are driven into the holes. They lie here in numbers up to and over one hundred, crowded together and heaped upon one another. Fusion begins soon

and the larvæ are gradually converted into a flattened cake. The larger cakes thus made measured four by three millimeters. The body of such a cake is a continuous flattened mass in which there is no indication of the component larvæ, but the rounded ends of the larvæ that have last fused with the general mass remain for a time distinguishable. Owing to their blue coloration the ends of the larvæ may be recognized in these and the other compound masses even after the outline of the larva has been completely lost.

As already stated the smaller compound masses metamorphose without difficulty. The coalesced larvæ may be made to attach to cover glasses, slides, etc. Larger masses composed of about twenty larvæ underwent a partial metamorphosis. Such masses were laid upon bolting cloth to which they readily attached. The larges masses were hung in small bolting cloth bags in a live box. Whether owing to bad handling or more probably to some inherent difficulty, they did not metamorphose but soon died.

The ease with which larvæ of the same species may be made to fuse together suggests that larvæ of different species might likewise be induced to coalesce. Some experiments along this line could not fail to be of interest.

IV

In the tendency to fuse with the production of a plasmodium, the dissociated cells of sponges resemble the amœbocytes (amœbulæ) of the mycetozoa and Protomyxa. The regenerative power of the plasmodium has an interest both theoretical and economic in itself. But it is the tendency to fuse displayed by the cells that have been forcibly broken apart, which constitutes the fact of most general physiological importance. Discarding for the moment the word "cell" and speaking of the protoplasm of a species as a specific substance, the phenomena may be restated to advantage in the following way.

A mass of sponge protoplasm in the unspecialized state typically exhibits pseudopodial activities at the surface. In

lieu of more precise knowledge it is useful to regard the pseudopodia as structures which explore and learn about the environment. On coming in contact two masses of the same specific protoplasm tend to fuse. This tendency is probably useful (*i. e.*, adaptive) in that the additional safety (from enemies and "accidents") accruing from increase in size of the mass more than compensates for the reduction in number of the individual masses that start to grow (rearing of sponges shows that masses of good size frequently withstand conditions that effectually wipe out the very small masses.) Unlike specific substances (protoplasms of quite different species) do not tend to fuse.

To the many biologists who have found ideas and observations of deep interest in the papers on protoplasmic activities by Professor and Mrs. E. A. Andrews (G. F. Andrews), the statement just made will have a familiar sound. Mrs. Andrews in her essay on The Living Substance as Such and as Organism[9] and her paper on The Spinning Activities of Protoplasm[10] makes, it would appear from subsequent confirmations, a definite advance in our knowledge of the intimate structure of protoplasm. But it is her generalizations, based on singularly acute observations, with respect to the *behavior* of protoplasm, that have especially influenced my own work. The particular generalizations referred to may be so formulated:

1 Protoplasm tends to produce a viscous, pellicular layer with formation of pseudopodial outgrowths over the surface, whether external or internal to the mass, which establishes contact with the environmental medium.

2 Pseudopodia from adjacent masses of the same specific substance tend to fuse. Thus actual connections which can be made and remade, and along which transference of substance takes place, are established between the masses.

That these phenomena are observable in widely separated groups of metazoa has been also shown by Professor Andrews

9 Suppl. to Journ. Morphology, vol. xii, no. 2, 1897.

10 Journ. Morphology, 1897.

in a series of brief studies marked with his well known skill and accuracy of observation and statement. I fully agree with him as to the great importance of the facts.

The general point of view entertained by Mrs. Andrews in her much discussed essay is perhaps not everywhere clear to me. It is manifest however that she consistently subordinates the idea of the individual, whether entire organism or cell, to that of the specific substance of which it is but a more or less detached piece. As far as the cell is concerned this point of view seems to be essentially that of Sachs and Whitman. Mrs. Andrews extends it to the whole organism, and I may say that this way of looking at an animal or plant (or piece of the same) is in my opinion a habit of mind that will justify itself and indeed is doing so today, in that it leads to discoveries concerning the nature of protoplasms as revealed by what they can do.

University of North Carolina,
Chapel Hill, N. C.
October 29, 1907.

FISHES OF NORTH CAROLINA; A REVIEW

BY JOSEPH HYDE PRATT

There has just been issued by the North Carolina Geological and Economic Survey Volume II on The Fishes of North Carolina. This volume has been prepared for the Survey by Dr. H. M. Smith, Deputy U. S. Commissioner of Fisheries. The object of this publication is to give to the people of North Carolina and to others a more accurate knowledge of the abundance, distribution, habits, migrations, spawning, food value, etc., of the fishes in the belief that such knowledge will lead to a fuller realization of the economic importance of the fishery resources to the State. For this reason, it has been the special aim to make the report useful to all the fishing interests of the State. No essential technical considerations have been slighted but the scientific treatment has been adapted to the needs of fishermen and others who have had no opportunity to study ichthyology. It is most desirable that there be created a deeper interest in the welfare of both fishes and fishermen and a better understanding of the conditions and needs of the fishing industry with a view of placing this important branch on a permanent basis and making it yield an increasing revenue to both State and people. This volume will also be of interest to the layman and perhaps of special interest to the angler, as he will be able to make use of the work in the identification of species. As the scientific aspects of the subject have not been neglected, the work will also be found to have a value to icthyologists and zoologists in general.

As a means of identifying any fish that may be taken in any waters of the State, artificial keys have been prepared based on the external characters that commercial fishermen and anglers may readily appreciate and, further, there is a copious index of common names which gives a further clue to all the species whose size makes them objects of capture.

As Dr. Smith states: "Although the fish life of North Carolina is not of a new or distinctive type and bears a rather close resemblance to that of the adjoining States, it does nevertheless have some features of exceptional interest."

On account of the great variation in the topography of the State, the number, length and volume of the rivers and streams, the large, shallow sounds which fringe the coast, the long coast-line, and the wide variation in climatic conditions, there has been developed in North Carolina a fish fauna rich in both species and individuals. Some of the species found in North Carolina are peculiar to this State, while others which were first identified in this State, have later been found elsewhere. Other species exist in much greater greater abundance in this State than in others.

Among the more prominent features of the fish fauna in North Carolina, Dr. Smith mentions the following:

"(a) The abundance of certain anadromous fishes, whose numbers are scarcely surpassed in any other waters, the chief of these being the shad, the alewives, and the striped bass.

"(b) The variety and abundance of suckers, minnows, and sun-fishes in the fresh waters generally, and of darters in the headwaters of the streams on both sides of the Alleghanies.

"(c) The occurence in the sounds and along the outer shores of immense schools of mullet, squeteague, menhaden, blue-fish, croaker, spot, pig-fish, pin-fish and other food fishes.

"(d) The extension to the North Carolina coast of many species which are characteristic of the West Indies or Florida.

"(e) A few species of the Atlantic coast reach their southern limit in North Carolina (such as the cod and tautog) or

FISHES FIRST DESCRIBED FROM NORTH CAROLINA WATERS

PRESENT IDENTIFICATION	ORIGINAL NAME	COMMON NAME	TYPE LOCALITY	DESCRIBER AND YEAR
SILURIDÆ:				
Schilbeodes furiosus*	Noturus furiosus	Mad-tom; Tabby-cat	Neuse River	Jordan & Meek, 1889
CATOSTOMIDÆ:				
Moxostoma papillosum	Ptychostomus papillosus	Red horse; Shiner; White mullet	Catawba and Yadkin rivers	Cope, 1870
Moxostoma collapsum*	Ptychostomus collapsus	Sucking mullet; Small-mouth Red horse	Neuse, Yadkin and Catawba rivers	Cope, 1870
Moxostoma pidiense*	Ptychostomus pidiensis	Sucker	Yadkin River	Cope, 1870
Moxostoma coregonus*	Ptychostomus coregonus	Blue mullet	Catawba and Yadkin rivers	Cope, 1870
Moxostoma album*	Ptychostomus albus	White mullet	Catawba River	Cope, 1870
Moxostoma thalassinum*	Ptychostomus thalassinus	Sucker	Yadkin River	Cope, 1870
Moxostoma robustum*	Ptychostomus robustus	Red horse	Yadkin River	Cope, 1870
Moxostoma crassilabre*	Ptychostomus crassilabris	Mullet; Red horse; Red horse-mullet; Sucker-mullet; Golden mullet; Golden-finned mullet; Horse-fish Red fin; Trout-Sucker	Yadkin River	Cope, 1870
Moxastoma conus*	Ptychostomus conus	Sucker	Yadkin River	Cope, 1870
Moxostoma rupiscartes	Moxostoma rupiscartes	Jumping mullet; Jump-rocks	Catawba River	Jordan & Jenkins, 1889
CYPRINIDAE:				
Notropis pyrrhomelas	Photogenis pyrrhomelas	Fiery black minnow	Catawba River	Cope, 1870
Notropis niveus	Hybopsis niveus	Shiner; snowy minnow	Catawba River	Cope, 1870
Notropis chlorocephalus	Hybopsis chlorocephalus	Green-headed minnow	Catawba River	Cope, 1870
Notropis brimleyi*	Notropis brimleyi	Brimley's minnow	Cane River	Bean, 1903
Notropis chiliticus*	Hybopsis chiliticus	Red-lipped minnow	Yadkin River	Cope, 1870
Notropis altipinnis*	Alburnellus altipinnis	High-finned minnow	Yadkin River	Cope, 1870
Notropis umbratilis matutinus*	Alburnellus matutinus	Minnow	Neuse River	Cope, 1870
Hybopis labrosus	Ceratichthys labrosus	Thick-lipped minnow	Catawba River	Cope, 1870
Hybopis hysinotus	Ceratichthys hysinotus	High-backed minnow	Catawba River	Cope, 1870
PŒCILIIDAE:				
Fundulus rathbuni*	Fundulus rathbuni	Rathburn's killifish	Cape Fear River	Jordan & Meek, 1889
EXOCŒTIDAE:				
Cypselurus lutkeni*	Exocœtus lutkeni	Flying fish	Beaufort	Jordan & Evermann, 1896
PERCIDAE:				
Boleosoma maculaticeps*	Boleosoma maculaticeps	Spotted-head darter	Catawba River	Cope, 1870
Etheostoma rufilineatum	Pœcilicihthys rufilineatum	Red-lined darter	French Broad River	Cope, 1870
Etheostoma swannanoa*	Etheostoma swannanoa	Swanannoa darter	Swannanoa River	Jordan & Evermann, 1889
Etheostoma vulneratum	Pœcilichthys vulneratus	Red-spotted darter	French Broad River	Cope, 1870
Ioa vitrea	Pœcilichthys vitreus	Glassy darter	Neuse River	Cope, 1870
TRIGLIDAE:				
Prionotus scitulus	Prionotus scitulus	Slim-flying trad; Flying fish; Flying trad; sea robin	Beaufort	Jordan & Gilbert, 1882
GOBIIDAE:				
Microgobius holmesi *	Microgobius holmesi	Holm's Goby	Beaufort	Smith, 1907

176

do not occur in noteworthy numbers further south (such as the white perch and striped bass)."

There have thus far been described from North Carolina waters 345 different species of fish; one species of lancelet; and one of lamprey. This number includes several species that have been introduced into the waters of North Carolina but which have become more or less established. Of these, 209 are marine or brackish water species; 125 are fresh water species; and 11 are anadromous or catadromous species.

Of this number, 29 species of fish were first described from North Carolina waters, of which 18 have as yet been found in no other State. These species are given in the following table together with the name of the species as described in the volume, name under which it was first described, the common name, type, locality, and the person by whom named and the date when the species was established. Those species marked by an asterisk have not been found as yet in any other State.

Under the heading of Systematic Catalogue of North Carolina fishes there is given a full list of all the species of fishes known to inhabit the fresh or salt waters of North Carolina and under each species there is given its technical name and original describer, its popular names, a brief synonomy, a diagnostic description and then a general account of their distribution, abundance, size, habits, food value, economic importance, etc., which have special reference to North Carolina. As an aid to the diagnostic description, a figure is given which shows the parts referred to and the names which designate them (Fig. 1)

Of the three great classes into which fishes and fish-like animals are divided, only the third is important in connection with the fishes of North Carolina, as the first two classes contain only one representative each. These classes are as follows:

KEY TO THE CLASSES OF FISHES AND FISH-LIKE ANIMALS

i. Animals with cartilaginous skeleton and without brain or skull; fins rudimentary and only on median line of body; mouth a slit surrounded by bristles; heart a tubular vessel without separate chambers; blood colorless; gillslits numerous, the respiratory cavity opening into the abdomen; inspired water discharged through a special abdominal pore.

LEPTOCARDII (lancelets).

ii. Animals with cartilaginous or bony skeleton; skull and brain present; heart developed as a cavity with at least two chambers; blood red.

a. Eel-shaped; skeleton cartilaginous; skull imperfect; mouth circular, suctorial; no jaws or paired fins; a single median nostril; gills pouch-shaped and numerous; skin naked; alimentary canal straight, without cœca; pancreas and spleen absent.

MARSIPOBRANCHII (lampreys, etc.)

aa. Skull well-developed; jaws distinct; fins usually highly-developed, some of them paired; skin usually scaly; nostrils at least two, not median; gill-openings a single slit on each side in most fishes (numerous in a few families); alimentary canal more or less convoluted; pancreas and spleen present.

PISCES (fishes).

Of the third class, Pisces, the North Carolina representatives fall into two easily recognized groups or sub-classes: (1) the Shark, Skates and Rays and (2) the True Fishes, which are distinguished anatomically as follows:

i. Skeleton cartilaginous; skull without sutures and without membranous bones; gill openings numerous (5 to 7) and slit like, the gills attached to the skin; tail heterocercal; skin tough, naked or covered with small rough scales, spines, or tubercles; air-bladder absent; jaws separable from skull; species viviparous or ovoviviparous, the eggs large and few in number; embryo with deciduous external gills.

SELACHII OR ELASMOBRANCHII (sharks, skates, rays, etc.)

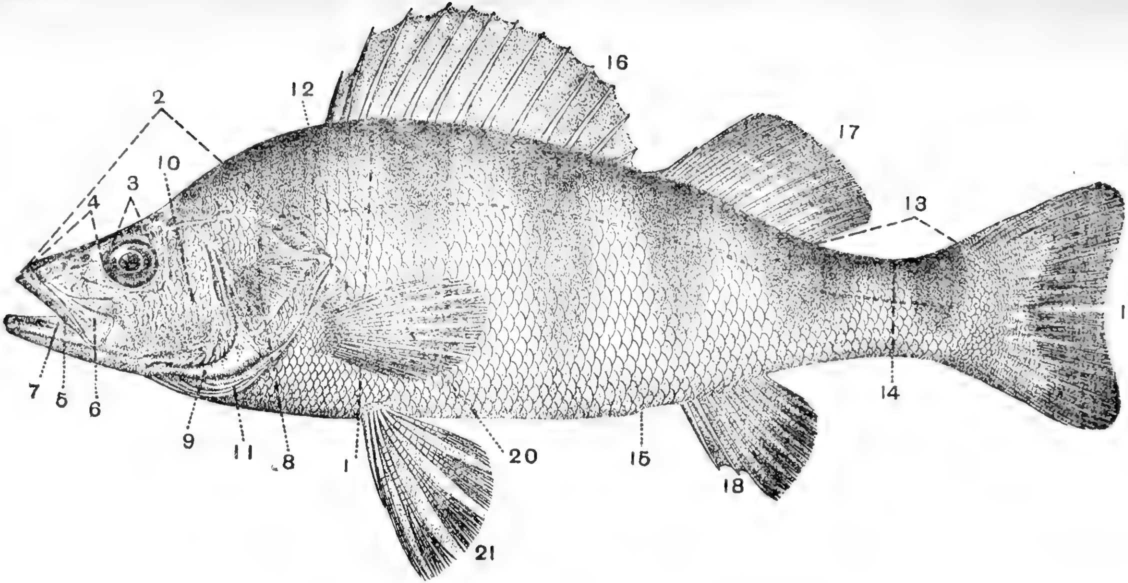


Fig. 1. CUT OF YELLOW PERCH SHOWING PARTS USUALLY REFERRED TO IN DESCRIPTIONS

1. Depth
2. Head
3. Eye
4. Snout
5. Premaxillary
6. Maxillary
7. Lower Jaw
8. Opercle
9. Subopercle
10. Preopercle and cheek
11. Branchiostegals
12. Lateral line
13. Length of caudal peduncle
14. Depth of caudal peduncle
15. Vent
16. Spinous dorsal fin
17. Soft dorsal fin
18. Anal fin
19. Caudal fin
20. Pectoral fin
21. Ventral fin

ii. Skeleton bony in all but a few families; skull with sutures and membranous bones (opercula, etc.); gill-openings a single slit on each side, the gills attached to bony arches; tail heterocercal or homocercal; body usually covered with numerous flat scales; air-bladder present or absent; jaws not distinct from the skull; species oviparous (exceptionally viviparous), the ova small and numerous.

TELEOSTOMI (true fishes).

In the first class are included 9 species of shark and 11 species of rays. In the second class (true fishes) there are 325 species. The 12 largest families included in these are as follows:

Cat-fishes	12	species	in	4	genera.
Suckers	18	"	"	5	"
Minnows	36	"	"	9	"
Killi-fishes	9	"	"	5	"
Mackerels	8	"	"	6	"
Carangids	17	"	"	8	"
Sun-fishes	17	"	"	10	"
Perches	24	"	"	12	"
Sea basses	11	"	"	7	"
Sparids	7	"	"	6	"
Drums	14	"	"	10	"
Flounders	11	"	"	7	"

The fisheries of North Carolina are of considerable economic importance to the State, approximating in value $2,000,000 per year, the catch being utilized largely for food purposes. Of the 347 species listed, there are about 90 that are of present commercial value, most of which are used for food. In the following table there is given a list of those that are used for this purpose. In this table there is given the common as well as the scientific name.

FISHES USED FOR FOOD IN NORTH CAROLINA.

Sturgeon (*Acipenser oxyrhynchus*).
Suckers (Family Catostomidae. North Carolina has more species of suckers than any other State; 8 species used as food).
Red Horse (*Moxostoma Crassılabre*).
Choly; shiner (*Hybognathus Nuchalis*).
Horned dace (*Semotilus Atromaculatus*).
Roach; shiner (*Notemigonus Crysoleucas*).
Carp (*Cyprinus Carpio*).
Eel, fresh-water eel (*Anguilla Chrısypa*).
Sea Herring (*Clupda Harengus Linnaeus*).
Hickory Shad (*Pomolobus Mediocris*).
Branch Herring, Alewife (*Pomolobus Pseudoharengus*).
Glut Herring, Shoal Herring (*Pomolobus Aestivalis*).
Shad (*Alosa Sapidissima*).
Menhaden (*Brevoortia Tyrannus*).
Brook Trout; Mountain Trout (*Salvelinus Fontinalis*).
Rainbow Trout; California Trout (*Salmo Irideus*).
Pike; Pickerel (*Esox Americanus* and *Esox Reticulatus*).
Mullets (*Mugil Cephalus* and *Mugil Curema*).
Bonito (*Sarda* Sarda) variety of mackerel.
Spanish Mackerel (*Scomberomorus Maculatus*).
Cero (*Scomberomorus Regalis* and *Cavalla*).
Sword-fish (*Xiphias Gladius*).
Pompano; Sun-fish (*Trachinotus Carolinus*).
Blue-fish (*Pomatomus Saltatrix*).
Cabio; Crab-eater (*Rachycentron Canadus*).
Star, Harvest-fish (*Peprilus Alepidotus*).
Butter-fish (*Poronotus Tricanthus*).
Calico Bass; Speckled Perch (*Pomoxis Sparoides*).
Flier (*Centrarcus Macropterus*).
Rock Bass (*Ambloplites Rupestris*).
Goggle-eyes; Warmouth (*Chaenobryttus Gulosus*).
Long-eared Sun-fish; Red-belly; Robin (*Lepomis Auritus*).
Blud Joe; Blue-gills; Blue Sun-fish (*Lepomis Incisor*).
Holbrook's Sun-fish (*Lepomıs Holbrooki*).

Sand Perch; Pumpkin-seed (*Lepomis Gibbrosus*).
Black Bass; small mouthed (*Micropterus Dolomieu*).
Black Bass, large mouthed (*Micropterus Salmoides*).
Pike Perch; Wall-eyed Pike (*Stizostedion Vitreum*).
Yellow Perch; Red-fin (*Perca Flavescens*).
Striped Bass; Rock-fish (*Roccus Lineatus*).
White Perch (*Marone Americana*).
Black-fish; Sea Bass (*Centropristes Striatus*).
Pig-fish; Hog-fish (*Orthopristis Chrysopterus*).
Snapper; Grunt (*Hæmulon Plumieri*).
Scup; Pin-fish (*Stenotomus Chrysops*).
Sailsois choice; Robin (*Lagodon Rhomboides*).
Sheepshead (*Archosargus Probatocephalus*).
Squeteague; Weak-fish; Sea Trout (*Cynoscion Regalis*).
Spotted Squeteague; spotted Weak-fish (*Cynoscion Nebulosus*).
Yellow Tail; Sand Perch; Perch (*Bairdiella Chrysura.*)
Spot (*Leiostomus Xanthurus*).
Croaker (*Micropogon Undulatus*).
Red Drum; Red-fish (*Sciaenops Ocellatus*).
King-fish; Sea Mullet; Carolina Whiting (*Menticirrhus Americanus*).
Sea Mullet; King-fish (*Menticirrhus Saxatilis*).
Surf Whiting (*Menticirrhus Littoralis*).
Black Drum (*Pogonias Cromis*).
Oyster-fish; Tautog (*Tautoga Onitis*).
Porgee, Spade-fish (*Chaetodipterus Faber*).
Cod (*Gadus Callarias*).
Flounder; Summer Flounder; Plaice (*Paralichthys Dentatus*).
Flounder, Southern, (*Paralichthys Lethostigmus*).
Flounder (*Paralichthys Albiguttus*).

All the fishes mentioned in this list are found to a greater or less extent in the markets, but only a few of them are of any large economic value to the State. Of the migratory fishes, the most conspicuous and the ones of most value are

the shad, alewives, hickory shad, striped bass, white perch, eel and sturgeon. Of the salt water fishes would be included the mullets, squeteagues, Spanish mackerel, croaker, spot and menhaden. The principal fresh water fish is the large-mouthed black bass. The spotted squeteague, pig fish, hickory shad and black bass are taken in larger quantities in North Carolina than in any other State.

On account, however, of over-fishing and non-enforcement of present laws relating to the fisheries, the industries are deteriorating and in some instances quite rapidly. Unless the State will provide prompt and adequate protection to the shad, alewives, striped bass and other species which are beginning to show a decrease in abundance, they will soon share the same fate as the sturgeon.

There is no reason why the fisheries of North Carolina should not be maintained for an indefinite period and even be very greatly improved; and to this end the session of the Legislature of 1907 created a Fsh Commission, but with very limited powers. It is to be hoped that at the session of 1909 the powers of the Fish Commission will be increased so that it will be in a position to prevent the causes of decline in these industries and be able to utilize all resources for building up and increasing the abundance of fish.

The Geological and Economic Survey, in cooperation with the United States Bureau of Fisheries, has carried on certain lines of work in regard to the protection and reproduction of the fishes of North Carolina, conducted through the Biological Laboratory at Beaufort, the hatchery at Edenton and the temporary hatching stations near Weldon. A number of fish have been introduced into the waters of North Carolina, some of which have become widely distributed and firmly established, such as the rainbow or California trout and the carp.

Large numbers of native fishes from outside hatcheries have been planted in the State, among these being the brook trout, large-mouthed and small-mouthed black basses, various sun-fishes, and several kinds of cat fishes.

REVIEWS

Van Nostrand's Chemical Annual, 1907. First Year of Issue. Edited by John C. Olsen, A. M., Ph. D. New York, D. Van Nostrand Co. x – 496 pp. The "Chemiker Kalendar" has long been a most useful publication but American chemists have desired a similar publication in English. In the new Annual Professor Olsen has improved upon the German model and produced an extremely satisfactory reference work. It consists exclusively of tables of physical and chemical data and lists of pnblications. The physical constants of inorganic and organic compounds are given in two tables, comprising nearly one half of the book. It is a pleasure to find frequently definite values for solubilities. The "Review of Chemical Literature" consists of a classified list of the more important articles published in the Journals and also a classified list of books, the time covered being from Jan. 1, 1905 to June 1, 1906. It is cause for congratulation that Professor Olsen undertook the editorship of a book which is so indespensible to the chemist. The execution of the mechanical part is excellent. A. S. W.

Solubilities of Inorganic and Organic Substances. A hand-book of the most reliable quantitative solubility determinations. Recalculated and complied by Atherton Seidell. 8vo X - 367 pp. D. Van Nostrand Company. New York, 1907. The only dictionary of chemical solubilities has been Comey's which was published in 1894. Although it is a book of great value there are several defects which detract from its usefulness. It contains no organic substances but we find instead a great variety of rare inorganic double salts. Too many unreliable determinations are incorporated and the arrangement is not consistent throughout so that it is fre-

quently troublesome to locate a compound. Seidell has introduced a large number of important organic substances, the selection of inorganic compounds is more satisfactory, the arrangement is logical throughout, and the determinations are more reliable. Greater reliability was arrived at with much labor by recalculating the various determinations to a common basis and drawing curves through the points plotted. Selections were then made after comparing the curves and studying the methods of determination. An index adds to the value of the book. Every chemist should have access to this thoroughly satisfactory dictionary, in fact it should be in every working scientific library. A. S. W.

JOURNAL

OF THE

Elisha Mitchell Scientific Society

VOL. XXIV
1908

WITH ONE PLATE

ISSUED QUARTERLY

THE UNIVERSITY PRESS
CHAPEL HILL, N. C.

TABLE OF CONTENTS

JOURNAL

OF THE

Elisha Mitchell Scientific Society

MAY, 1908

VOL. XXIV NO. 1

MICRO-STRUCTURE AND PROBABLE ORIGIN OF FLINT-LIKE SLATE NEAR CHAPEL HILL, NORTH CAROLINA

H. N. EATON

Two miles south of Chapel Hill, North Carolina, along the bed of a small stream known as Morgan's Creek occur extensive exposures of a series of rocks whose general strike is east and west. From Purefoy's Mill on the Pittsboro road eastward along the stream bed to a point three miles distant on the Mason farm, these rocks are of the same general character, and consist of a series of conglomerates, sandstones, and flint-like slates lying in places upon felsite, and dipping southward 50 to 70 degrees. Sills of fine grained acid and basic igneous rocks are frequently found intercalated in this series, and all the rocks are cut by a set of basic dikes. The flint-like slates alone form the basis for the present paper.

This series of rocks has often been included in a great formation of slates and schists of debatable age, extending from Virginia

southwesterly across central North Carolina into South Carolina, and known as the Carolina Slate Belt. Ebenezer Emmons[1] placed all these rocks in his Taconic system, and W. C. Kerr[2] considered that they belonged to the Huronian. Without considering the vexed question of age, we turn to the views expressed by former writers as to the origin of the flint-like, slaty members of the series.

As early as 1822 the existence of novaculite in Orange County, North Carolina, was noted by Denison Olmstead[3]. In 1828 the same writer[4] again mentioned the novaculite of the slate formation, and stated that the most valuable bed was found at McCauley's quarry, seven miles west of Chapel Hill. The rock here is olive green in color, has a horny look, and is transparent on thin edges.

Emmons[5] described this rock under the head of quartzite as follows: "Color, bluish black passing into purple, grayish, white and green of several shades, and sometimes banded; texture, fine when compared with the finest sandstones; translucent on edges; fracture, flat-conchoidal and frequently brittle, or it may be tough in the mass, but small pieces easily chip off with a light blow. It passes on the one hand into a fine grit, and on the other, into the compact slate and a condition like flint. When struck with the hammer, it is sonorous like cast iron. It is rarely if ever a simple substance like limpid quartz as it usually weathers and loses thereby its homogeneity; besides it is often porphyritic or porphyrized, and frequently the fresh fracture is dotted with small limpid crystals of quartz, which crystalized out from the mass when it was in a semi-fluid state."

---

1 Geological Report of the Midland Counties of North Carolina, New York, 1856, pp. 38-73.

2 Report of the Geological Survey of North Carolina, vol. 1 Raleigh, 1875, pp. 131-139.

3 American Journal of Science, Series 1, vol. 5, 1822, p. 262.

4 American Journal of Science, Series 1, vol. 14, 1828, p. 238.

5 Ibid. pp. 69-70.

Albert Williams, Jr,[1] writing in 1888, stated that novaculite was quarried on an extensive scale a few miles west of Chapel Hill.

In his monograph on the Arkansas novaculite, published in 1892, L. S. Griswold[2] cites the above references to Olmstead and Albert Williams, Jr. This writer, in the course of a description of that type of novaculite known as the "Arkansas Stone", says, "The only other stone in this country which resembles the Arkansas Stone and is worked, is that of North Carolina, but the greasy talcose appearance of the latter suggests that its internal structure differs from that of the true novaculite."

H. B. C. Nitze[3], in 1896, describing the rocks of the Carolina Slate Belt, writes thus under the heading, "Quartz Rocks—The Volcanic Series":

"The crypto- crystalline varieties of quartz (flint, chert, hornstone, agatized, chalcedonic) are of especial interest, and warrant a careful consideration. It is again deplored in this connection that the present report did not allow the time for a microscopic study of the thin sections. Such cherty, flint-like masses have been described from the Sam Christian, Moratock, Silver Valley and Hoover Hill mines. It is at present the opinion that these rocks belong to the class of ancient (pre-Cambrian) acid volcanics, and in many respects analogous to, and probably contemporaneous with, similar rocks of South Mountain in Maryland and Pennsylvania, whose discovery was first announced by the late Dr. Geo. H. Williams[4]. Miss Florence Bascom[5] has described the origin, devitrification and structure of the acid types of these rocks. Dr. Williams[6] has outlined the general distribution of the ancient vol-

---

1 Mineral Resources of the United States, Calendar year 1887, Washington, 1888, p. 772.

2 Annual Report of the Geological Survey of Arkansas for 1890, vol. 3, 1892, Whetstones and the Novaculites of Arkansas, pp. 21 and 22.

3 North Carolina Geological Survey, Bull., No. 3, Gold Deposits of North Carolina, by H. B. C. Nitze and G. B. Hanna, 1896, pp. 37-38.

4 The Volcanic Rocks of the South Mts. in Pa. and Md., Am. Jour. Sci., vol. 44, Dec., 1892, pp. 482-496. Scientific American, Jan. 14, 1893.

5 Journal of Geology, vol. I, 1893, pp. 813-832.

6 Ibid. vol. 2, 1894, pp. 1-31.

canic rocks along the eastern border of North America. These rocks are analogous to the hälleflintas and eurites of Southern Sweden, described as volcanic rocks by Nordenskjöld. They would also correspond to Hunt's pre-Cambrian petro-silex rocks, called by him the Arvonian, being below his Huronian.

"The hornstones have every appearance of being acid feldspar-quartz rocks, and will probably be found, on further study, to belong to the class of apo-rhyolites, a term introduced by Miss Bascom to denote a devitrified rhyolite. Emmons[1] describes the type very well under the head of quartzite. They resemble perfectly crypto-crystalline quartz, and on weathering present an earthy, yellowish surface. The color of the fresh rock is drab, bluish to almost black; translucent on edges; fracture flat conchoidal; sometimes banded, showing flow structure, etc." On pages 41 and 42 of the same report the following is quoted from Dr. Williams'[2] article: "'In a drive from Sanford to Chapel Hill an abundance of the most typical ancient lavas, mostly of the acid type, was encountered'" - - - - "'Another locality in the volcanic belt was visited on Morgan's run, about 2 miles south of Chapel Hill. Here are to be seen admirable exposures of volcanic flow and breccias with finer tuff deposits, which have been extensively sheared into slates by dynamic agency.'" The above is repeated verbatim by the same author[3] the same year (1896) in an article entitled, "Some Late Views of the So-called Taconic and Huronian Rocks in Central North Carolina."

The tenor of those parts of Nitze's paper just quoted referring to the origin of the fine grained quartz rocks, seems to be that these rocks are closely connected with the ancient surface lava flows which are so common throughout the region. He states that none of them were examined miscroscopically, but suggests that the hornstones will probably be found to be apo-rhyolites. The references to the work of Dr. Williams and Dr. Bascom on the structure and devitrification of ancient acid lavas show that Nitze

---

1 Geological Report, Midland Counties of N. C., New York, 1856, p. 51.

2 Journal of Geology, vol. 2, 1894, pp. 1-31.

3 This journal, vol. 13, Part Second, July- Dec., 1896, pp. 53-72.

considered the formation of the hornstones and flinty slates as due to a change in the latter rocks. The existence of tuff deposits along this part of Morgan's Creek mentioned by Williams and quoted by Nitze is strongly discredited by Professor Collier Cobb, who has had occasion to learn thoroughly the structure of the region in question during the course of his work at Chapel Hill. Professor Cobb, however, takes his classes to such tuff deposits southwest of the village, and it is these that Williams and Nitze have evidently confused with the slates of Morgan's Creek two miles south of Chapel Hill.

As Professor Cobb has pointed out to the writer, these slates are bedded alternately with sandstones and conglomerates. The conglomerates are composed of well-rounded pebbles of several kinds of volcanic rocks, but are by no means volcanic agglomerates. The slates are coincident in dip with the sandstones and conglomerates with which they are associated, and, from all field evidence obtainable, seem to have been deposited as regular members of the sedimentary series.

Specimens of the rock for investigation were obtained near the dam at Purefoy's Mill. The general macroscopic description given by Nitze applies very well to the rock from this locality. In handspecimen, the rock is olive green in color, weathering to brownish clay; banding faint, becoming more apparent on a weathered surface; appearance waxy; structure dense and compact, with occasional minute reflecting crystal surfaces; translucent on edges; fracture conchoidal; very brittle; hardness 6.5. Its resistance to abrasion is evidenced by the fact that all of the arrow heads and spear heads of primitive man found in the vicinity of Chapel Hill are made of this material.

Microscopically, this slate is seen to be a true crypto-crystalline rock, containing the minerals feldspar, quartz, kaolin, and epidote. The groundmass is composed of very fine quartz crystals and minute feldspar fragments through which kaolin scales are plentifully scattered. Larger crystals of feldspar form a prominent feature, and occur individually or in groups throughout the groundmass. Sections cut at right angles to the lamination show that the kaolin scales occur in distinct bands varying in width

from .25 to 1.1 mm. To the existence of these bands is due the laminated appearance of the rock in hand specimen. In some cases, also, there seems to have been a rough assortment of the larger feldspars in bands, although this occurrence was not observed to be universal.

The feldspar is plagioclase, and occurs in crystals varying in size from the very minute particles of the groundmass up to .286 mm. in diameter. The average diameter of the larger crystals is from .065 to .1 mm. The form is usually sub-angular, although rounded crystals are seen, suggestive of a clastic derivation. All the crystals polarize separately. Some crystals are intimately interlocked. Others have deep re-entrants into which the silica of the groundmass protrudes, suggesting a partial resorbtion of the feldspar by the groundmass. Albite twinning is universal, the maximum angle of the striations in the zone perpendicular to M lying between 10 and 16 degrees. Hence the plagioclase mixtures lie between basic oligoclase and andesine. The crystals show little if any decomposition. The largest feldspar noted, .286 mm. in diameter, is nearly round, is completely encased in a thin rim of greenish glass, and lies in a rubble of small angular feldspar fragments.

The crystals of the groundmass all polarize separately and exhibit low interference colors. The grains are extremely irregular in outline, and are closely intelocked. The average diameter is .015 mm. Many of these grains are seen to be plagioclase from the albite striations. Many are quartz, but owing to the difficulty of distinguishing between quartz and feldspar in very small angular fragments, it is not possible to state definitely the percentage of each mineral. That much free silica is probably present, however, is indicated by the high total percentage of silica in the rock.

Kaolin occurs in minute scales. In the narrow bands above noted, kaolin is by far the most abundant mineral, and the scales lie very close together. It is likewise found in less abundance in every part of the rock. The diameter of the scales varies from .0026 to .0052 mm.

Epidote occurs rarely in minute grains in small clusters. The interference colors are of a low order.

A partial analysis of the rock by Dr. A. S. Wheeler, associate professor of Chemistry in the University of North Carolina, gives the following results:

Silica	77.54 per cent.
Alumina	13.51 per cent.
Iron oxide	1.17 per cent.
Lime	1.10 per cent.
Magnesia	0.23 per cent.

This analysis confirms the microscopic determination.

Hand specimens and thin sections of a somewhat similar fine grained siliceous rock from Gold Hill, N. C., collected last summer by Mr. F. B. Laney of the North Carolina Geological Survey, were lent the writer by the State Geologist, Dr. Joseph Hyde Pratt. A hasty examination of thin sections of the latter rock reveals its close resemblance to the Purefoy's Mill material, the main difference between the two being that the feldspars in the Gold Hill rock are uniformly larger.

Griswold[1] defines novaculite as "a fine-grained, gritty, homogeneous, and highly siliceous rock, translucent on thin edges, and having a conchoidal or sub-conchoidal fracture." The Purefoy's Mill rock differs from the Arkansas novaculites in its lower silica content, and in containing kaolin and feldspar in abundance. It resembles the true novaculites in its general physical character.

SUMMARY AND CONCLUSIONS AS TO ORIGIN.

Field evidence shows that the flint-like slate found at Purefoy's Mill is a member of an undoubted sedimentary series, with distinct lamination or stratification coinciding in dip with the other members of the series. Microscopic study reveals the fact that a mechanical sorting and arrangement of the kaolin particles in layers took place prior to consolidation.

Professor Cobb is of the opinion that the rock owes its origin to the consolidation of fine volcanic sand sorted by and deposited in deep water, or that the sediment may have been derived from the

---

(1) Annual Report of the Geological Survey of Arkansas for 1890, vol. 3, p. 18.

felsites and rhyolites on which it rests, its crystalline structure being due to subsequent metamorphism.

The writer, rather, believes that the rock has remained essentially unchanged since its consolidation, and that its formation was similar to that of arkose, viz: that its component minerals are the detrital fragments of a rock or rocks rich in quartz and feldspar. Many of the feldspars are rounded, suggesting a clastic origin, and are roughly arranged in layers parallel with the kaolin bands. The chemical analysis, as far as it was carried out, is very much like the analysis of the average rhyolite, and it is highly probable that the materials of which the rock is composed were derived from such acid volcanic rocks as occur in great abundance in the vicinity.

The writer wishes to express his indebtedness to Professor Cobb for suggestions in preparing this paper, and also to Dr. Pratt and Mr. Laney for kindly loaning him material for comparison.

Department of Geology,
University of North Carolina,
Chapel Hill, N. C.

FIELD FOR ECONOMIC PLANT BREEDING IN THE COTTON BELT*

DAVID R. COKER

In considering any subject related to the present condition of Southern Agriculture, it is well to remember that our section has not completely recovered from the effect of the civil war and the ensuing period of negro rule. This cannot be but plain to the student of Southern Agricultural conditions and is largely caused by the almost complete paralysis of our educational system during and for some years after the war.

A large percentage of our farmers, not having had the opportunity to obtain an education, have been unable to keep full pace with the advance of their profession. The influence of our Agricultural Colleges and the missionary work of such men as Dr. J. M. McBryde, Col. J. S. Newman, Prof. W. F. Massey, Mr. E. McIver Williamson and Editors Jackson and Hunnicutt are, however, plainly evident in the general and rapid improvement of conditions.

Though great advances along many lines have been made, the subject of plant breeding and its vital relation to agriculture has hardly begun to attract attention in our section. Scarcely any of our farmers have the slightest conception of what plant breeding means, and there is now almost no supply of pedigreed seed of any of our staple crops. Our farmers, however, can be counted on to buy scientifically bred seed and devote some attention to seed selection, as soon as the great value of pure breeding is impressed upon them. Our Agricultural Colleges and farm journals have a gread field for missionary work on this subject, which, as yet, they have scarcely touched.

*Read before the American Breeders Association, Washington, D. C., January 30th, 1908.

There are for sale in the South numerous so called varieties of seed which are advertised under high sounding names and with most extravagant claims of productive capacity. Many of these, however, prove to be mixtures of types and are frequently found to be worse than valueless. Plant breeders, as well as farmers, would welcome an effort by the National and State Governments to stop this pestiferous class of swindling, and I hope the Association will take some steps to this end for the general good and protection of its members.

The importance of plant breeding to the south cannot better be shown than by calling attention to the value of some of the work that has already been done.

The earliest work of this kind that is known of by the writer was undertaken before the war by Hon. John Townsend of Edisto Island, who succeeded in improving a strain of Sea Island cotton until its length was about two inches. I am informed that he invariably got $1.00 or more per pound for this cotton as long as he lived. Other Sea Island planters have kept up a more or less perfect system of breeding to the present day, and to this, in part at least, is undoubtedly due to the admitted pre-eminence of South Carolina Sea Islands.

Valuable varieties of upland long staples have been originated by Mr. Allen and Mr. Griffin of Mississippi and Mr. Stoney and Prof. C. L. Newman of South Carolina. Prof. Newman has also done some remarkable work on field peas.

The experiment Stations of all the cotton states are, I believe, now doing more or less plant breeding, but most of their work has not advanced far enough to have general effect on agricultural conditions.

The work of the National Plant Breeding Department, under the direction of Dr. H. J. Webber, stands preeminent in the breeding of those of our economic plants to which attention has been given.

The success of this department with pineapples, citrus fruits, cotton and tobacco are no doubt more or less familiar to all of this audience.

The Columbia, bred by Dr. Webber personally, is the first of his cottons to be distributed by the Department of Agriculture.

It has yielded with the best of the varieties tested at our State Experiment station, and its money out-turn was the greatest of any, on account of the premium which its long staple commands.

My own experiments with this cotton seem to coincide with those obtained at Clemson the last season. I tested it with nine other varieties and, though the general results were not conclusive, owing to irregularity of stand, Columbia undoubtedly stood first in money value.

Dr. Webber's Citranges are also an important addition to our economic plants, as they provide an entirely new class of fruits for the cotton belt.

A plant of Rusk Citrange which fruited in my garden last season has thus far proved entirely hardy. The delicious ade made from this fruit may soon be expected to alleviate the situation in the broad area of southern prohibition territory.

I would like to mention the work of a number of the men in the Bureau of Plant Breeding, but refrain from lack of space. I *must* say, however, that Mr. A. D. Shamel has obtained results with shade grown tobacco that deserve the widest notice and commendation. He has, in fact, revolutionized that industry. Mr. Orton also, in saving the cotton plant from extinction over considerable areas, has earned the gratitude of the cotton states.

The production of varieties of cotton similar to Columbia, suited to each section of the south, is one of the most promising opportunities now in view for southern plant breeders. This work is especially important to the eastern part of the belt where upland cottons average less than one inch in length of staple and sell in the markets of the world at a lower price than any except East Indians.

It should be noted that most of Dr. Webber's promising new cottons, including Columbia, originated with selections from existing varieties and not from hybrids.

My method of cotton breeding is similar to that originated by Dr. Webber, but differs in a few details. I started with a determination to breed, if possible, an up-land cotton of maximum production that would command a staple premium. All extra staple varieties then known to me were much lower in yield than

the best short staple sorts. I have, therefore, from the first examined only the most productive plants, and of these only the ones which show an increase in length of lint are selected for breeding. I give the plants a distance of 4 by 4 or 5 by 5 feet and have incidentally made the interesting discovery that on good soils these distances produce more cotton than the usual farm method of crowding in the drill. I find it a good plan to have two breeding plats, one on heavy and one on light soil, putting part of the seed of each mother plant on each plat under the same breeding number. Before selection is begun I take one seed with lint attached from each of a dozen plants on each breeding row and mount them. By a comparison of these a quick approximation can be made of the average performance of each breeding number in length and percentage of lint. Selections are then made from every number not palpably deficient in some cardinal point, for I find it impossible to judge with the eye the relative yield of different rows of cotton. A record of the exact yield of each row on both plats is, therefore, kept and if the same number shows maximum yields as well as other desirable qualities on both the light and heavy soil rows, there can be little question of the inherent quality of the selections made from it. Selections from rows of poor yield are, of course, discarded unless very exceptional.

My best number last season showed a production about 10 per cent greater in both plats than any other row. It was also quite satisfactory in length and percentage of lint, largeness of boll and other desirable characteristics, and I hope to make from it a variety as good as, or better than Columbia.

The low yield of corn throughout the cotton belt is presumptive evidence of both poor seed and inferior cultural methods.

The latter is being rapidly remedied, largely through the agitation begun by Mr. E. McIver Williamson of my own County, (Darlington County, S. C.) who has perfected a method of culture that not only produces large crops, but rapidly improves the soil.

Such corn breeding work as is now being carried on so generally and successfully in the middle states is almost unknown to the South. Here and there, intelligent farmers have improved

their own seed by selection in the field. None of them, however, that I know of has resorted to pedigreed breeding, and if any acclimated corn of pure pedigree is being offered to the farmers of the cotton belt, I do not know of it.

My own work, begun only a year ago, indicates as great variability in the yielding power of individual ears as has been noted by Mr. J. Dwight Funk and Prof. C. G. Hopkins of Illinois. A most notable result in my experiments was the absolute failure of the seed ear which in all visible points was best.

The limits of this paper do not allow mention of the breeding requirements of each of the many southern economic plants. Suffice it to say that nearly all of them (and their number is legion) can be greatly improved in quality and productive capacity by systematic breeding.

The record of southern plant breeding is, as yet, very short. Here and there, work has begun and quick and valuable results have invariably followed; but compared with what yet remains to be done, that already accomplished is indeed small.

No fairer or broader field exists in American Agriculture today than the field for economic plant breeding in the Cotton Belt.

HARTSVILLE, S. C.

NOTES ON THE LIFE-ZONES IN NORTH CAROLINA

C. S. BRIMLEY AND FRANKLIN SHERMAN, JR.

The old-established popular division of North Carolina into eastern, middle, and western sections, is familiar to us all. It is an interesting fact that a study of the available zoological records gives a somewhat similar division of the state into life-zones or areas.

This detailed study of the animal life of the state shows that, while a small number of species are widely distributed throughout all sections of the state, yet the majority show in some degree, a more or less restricted range within our borders, — and it is upon a study of all available records of these restricted forms, that our provisional map of the life-zones of the state is based. In these studies we have depended mainly on mammals, reptiles and batrachians. Fishes have been practically omitted, and birds and insects owing to their powers of flight and tendency to wander, have been used chiefly for confirmation, and even then we have relied principally on records of breeding birds, which would be more likely to be within their proper range.

It has been known that four of the recognized life-zones of North America are represented in our state. These are: — 1st, the Canadian, — 2nd, the Alleghanian (or Transition), — 3rd, the Upper Austral (or Carolinian), — 4th, the Lower Austral (or Austroriparian.)

1. *The Canadian Zone* in this state includes only the tops of the higher mountains. Aside from a few scattered records the places from which we have sufficient data to positively mark as belonging to this zone are, the higher altitudes in the Black Mountains, Roan Mountain, Grandfather Mountain (including

Blowing Rock), Bald Mountain in Yancey County, and the higher mountains in the vicinity of Highlands in Macon County,—although it is practically certain that more extended collecting and observation will show that this same zone includes also the tops of some other mountains, especially the Balsams, Mount Toxaway, and Pisgah Ridge. This zone does not extend below an elevation of 4,500 feet. The animals known to occur in this zone in this state and which do not normally extend into the zones of lower elevation, are named below. We include those species of birds whose nesting habitat is in this zone, though the same birds may of course be found in other zones when not nesting.

Mammals:

Carolina Red-backed Mouse (Evotomys Carolinensis).
Canadian Deer-mouse (Peromyscus canadensis).
Woodland Jumping-Mouse (Napaeozapus insignis).

Birds (breeding):

Golden-crowned Kinglet (Regulus satrapa).
Red-breasted Nut-hatch (Sitta canadensis).
Brown Creeper (Certhia familiaris).
Winter Wren (Olbiorchilus hyemalis).
American Cross-bill (Loxian minor).
Pine Siskin (Spinus tristis).
Carolina Junco (Junco hyemalis carolinensis).

Batrachians:

Black Salamander (Desmognathus nigra).
Purple Salamander (Spelerpes porphyriticus).
Yellow Salamander (Desmognathus ochrophea).

2. *The Alleghanian Zone* embraces a large part of our mountain region, including practically all between the elevations of 2,500, and 4,500 feet. In our map we have conservatively restricted this zone to the higher known ranges. We have record of the following species which are characteristic of this zone as contrasted with the more highly-elevated Canadian zone:

Mammals:

Common Flying-squirrel (Seiuropterus volans).

Deer-mouse (Peromyscus leucopus).
Pine-mouse (Microtus pinetorum).
Cotton-tail Rabbit (Lepus floridanus mallurus).
Dusky Bat (Vespertilio fuscus).
Common Mole (Scalops aquaticus).

Reptiles and Batrachians:

Viscid Salamander (Plethodon glutinosus).
Red Triton (Spelerpes ruber).
Hellbender (Cryptobranchus alleghaniensis).
Ground Snake (Carphophiops amoenus).
Chicken Snake (Coluber obsoletus).
Banded Rattlesnake (Crotalis horridus).

As the above-named species distinguish this zone from the Canadian, just so the following species distinguish it from he lower and warmer Upper Austral zone.

Mammals:

Star-nosed Mole (Condylura cristata).
Brewer's Mole (Scapanus breweri).
Smoky Shrew (Sorex fumeus).
Red Squirrel (Sciurus hudsonius).
Wood-chuck (Artomys monax).

Batrachians:

Daniel's Salamander (Spelerpes danielsi).
Mountain Salamander (Desmognathus quadrimaculatus).

3. *The Upper Austral Zone* seems to include (roughly speaking) all of our territory north and west of a line drawn from Suffolk, Va. to Raleigh, thence to Charlotte, and thence a little south of west to the South Carolina line at or near Tryon in Polk County, —except that part of the mountain region occupied by the Alleghanian and Canadian zones. The animals which occur in this zone in this state and which are generally considered to distinguish it from the higher and colder Alleghanian zone are:

Mammals:

Opossum (Didelphis virginianus).

Gray Fox (Urocyon cinereo argenteus).
Golden Mouse (Peromyscus nuttalli).
Little Mole Shrew (Blarina parva).
Twilight Bat (Nycticeius humeralis).
Georgia Bat (Pipistrellus subflarus).

Reptiles and Batrachians:

Marbled Salamander (Amblystoma punctatum).
Holbrook's Triton (Spelerpes guttolineatus).
Ground Lizard (Liolepisma laterale).
Brown King-snake (Ophibolus rhombomaculatus).
Muhlenberg's Terrapin (Chelopus muhlenbergi).

And this same zone is distinguished on the south and west by having the following animals whose range does not normally extend into the Lower Austral zone.

Mammals:

Chipmunk (Tamias striatus).
Deer-mouse (Peromyscus leucopus).
Cooper's Lemming (Simaptomys cooperi).
Meadow Mouse (Microtus pennsylvanicus).
Jumping Mouse (Zapus hudsonius).
Weasel (Putorius novaboracensis).
Mole Shaew (Blarina brevicauda).
Red Fox (Vulpes fulvus).

Reptiles and Batrachians:

Common Water-snake (Natrix fasciatus sipedon).
Wood Frog (Rana sylvatica).
Pickerel Frog (Rana palustris).
Red-backed Salamander (Plethodon erythronotus).

4. *The Lower Austral Zone* includes all of our territory south and east of the line already described for the eastern and southern boundary of the preceding (upper austral) zone. The number of animals occurring in this state in this zone but not ordinarily extending into the Upper Austral Zone is quite large, and includes the following:

Mammals:

Southern Fox Squirrel (Sciurus niger).
Cotton Mouse (Peromyscus gossypinus).
Cotton Rat (Sigmodon hispidus).
Rice-field Rat (Oryzomys palustris).
Roof-rat (introduced) (Mus alexandrinus).
Marsh Rabbit (Lepus palustris).
Southern Shrew (Sorex longirostris).
Carolina Mole Shrew (Blarina carolinensis).
Big-eared Bat (Plecotus mocrotis).

Birds:

A considerable number might be mentioned but are not needed to confirm the zone.

Reptiles:

Alligator (Alligator mississipiensis).
Joint Snake (Ophysauris ventralis).
Green Lizard (Anolis principalis).
Southern Water-snake (Natrix fasciata).
Pied Water-snake (Natrix taxispilota).
Hoop-snake (Abastor erythrogrammus).
Horn-snake (Farancia abacura).
Striped Chicken-snake (Coluber quadrivittatus).
Spotted Racer (Coluber guttatus).
Brown-headed Snake (Rhadinea flavilata).
Red King-snake (Ophibolus coccineus).
Red Snake (Cemophora coccinea).
Hog-nosed Snake (Heterodon simus).
Crowned Tantilla (Tantilla coronata).
Cotton-mouth Moccasin (Akistrodon piscivorus).
Ground Rattle-snake (Sistrurus miliarius).
Diamond Rattle-snake (Crotalus adamanteus).
Smooth Terrapin (Pseudemys concinna).
Florida Terrapin (Pseudemys floridanus).
Rough Terrapin (Pseudemys scripta).

Batrachians:

Carolina Tree-frog (Hyla cinerea).
Squirrel Tree-frog (Hyla squirella).
Pine-woods Tree-frog (Hyla femoralis).
Dwarf Toad (Bufo quercicus).
Narrow-mouth Toad (Engystoma carolinense).
Margined Salamander (Stereochilus marginatus).
Dwarf Salamander (Manculus quadridigitatus).
Mole Salamander (Amblystoma talpoideum).
Ditch Eel (Amphiuma means).
Southern Water-dog (Necturus punctatus).
Mud Eel (Siren lacertina).

In outlining this map the most important step has been to locate the line separating the lower and upper austral zones. In placing this line where we have it, we have been influenced by the following data: The Dismal Swamp region, which lies partly in the northern end of Camden county, is known to have decidedly lower austral affinities, so that our line would seem to start west of this swamp. The only section in the northeast part of the state which has enough records to furnish a reliable guide is the southeastern part of Bertie county, where Sans Souci and Avoca have on record five distinctively lower austral forms, to two upper austral. Meagre data from Jackson (Northampton County) and Tarboro (Edgecombe Co.) indicate a mixed fauna at both places, and therefore we have run the line between them. Raleigh is really the strongest point in locating this line. Abundant data indicates that the fauna of Raleigh and vicinity is thoroughly mixed, with no decided preponderance in either direction,—therefore we have run the line directly through Raleigh. This gives practically a straight line from Raleigh toward Suffolk, Va., until the state line is reached at Chowan River.

West of Raleigh and east of the mountains our data is scant. Cary, with one decidedly upper austral form (Chipmunk) which does not occur at Raleigh, finds a place above the line, while Apex with one lower austral form is below it. It is interesting to note here that the Chipmunk recorded from Cary was taken not more than seven miles from Raleigh but has never been taken actual-

ly at Raleigh, while the Florida Terrapin, (a very decidedly lower austral form) has been taken in north-west Johnston county, but is not known at Raleigh. This gives further warrant for running the dividing line directly through Raleigh.

The line, passing between Cary and Apex, runs straight to Charlotte. Southern Pines, many of whose insects are known, shows strong lower austral affinities, while Stanly and Cabarrus counties each contribute one lower austral record. As Salisbury and Statesville both show records which would tend to exclude them from the lower austral zone, we have run the line straight to Charlotte so as to leave these points in the upper austral, but including parts of both Stanly and Cabarrus counties in the lower austral.

From Charlotte we have run the line slightly south of west, so that it crosses the South Carolina line at or near Tryon in Polk County. This latter locality seems to be (biologically) one of the most remarkable in the state. Its vicinity within a radius of a few miles is so varied in elevation and temperature that we have records of lower austral, upper austral, and Alleghanian forms, and there may be an infusion of strictly Canadian forms on the tops of the higher mountains of that locality. Of the strictly lower austral forms known at Tryon we may mention the Green Lizard, and a species of true Scorpion, the latter having never yet been taken at any other place in the state.

It may be well to mention a few rather exceptional records. Coopers Lemming, — recorded as an inhabitant of sphagnum swamps which are generally considered to present Alleghanian tendencies,—has been taken at Chapanoke in Perquimmans county. The Diamond Rattle-snake, — considered to be a decidedly lower austral form, — has been recorded at Jackson, Northhampton Co. The Red-backed Salamander, — not known at Raleigh and a distinctively upper austral form, — has been taken at Greenville, Pitt Co. At Kinston the Wood-Frog and Pickerel Frog (both considered to be upper austral species) have been taken. The Weasel (upper austral) has been taken at New Bern. The Glass Snake,— a typically lower austral form, — has been taken at Statesville. In Transylvania county there is record of the Mole Salamander, which is a distinctively lower austral form. Insects of normally

lower austral habitat have been taken at Andrews in Cherokee Co. and near Franklin in Macon Co. The Green Lizard (lower austral) is also said to occur along the Little Tennessee River in Graham or Swain Counties, but this record is open to question.

At Weaverville, Buncombe County, the Big-eared Bat (lower austral) has been recorded.

These exceptional records, while in our opinion not sufficiently numerous or consistent to change the course of the faunal lines as shown on the map, serve to emphasize the fact that no faunal lines or zones can be claimed to be absolute. Animals typical of one zone will occasionally wander into a neighboring zone. It is therefore not surprising to find a typically lower austral form as much as twenty to forty miles north or west of the faunal line, or on the other hand to find a distinctively upper austral form a similar distance east or south of this line, — and this overlapping of forms along the edges of the zones occurs with special frequency among those animals which move rapidly from place to place and which may therefore from hunger, fright or other causes become restless and wander out of their normal range. But it would be worthy of note if a *distinctively* upper austral form were found to occur regularly and in any degree of abundance, in the warmer parts of our state which are well within the Lower Austral zone as defined on our map. In this connection we would call attention to the localities of Cape Hatteras, Beaufort, Havelock (Lake Ellis) and Wilmington. From these four localities we get a total of 46 characteristic records, every one of them lower austral. But when we go nearer to the line to the north and west as at Greenville, Tarboro and southeastern Bertie County, we strike scattering upper austral records. The few upper austral rocords for New Bern and Kinston are of such character as not to materially affect their standing as strictly lower austral localities. The presence of several lower austral records in the southern part of our mountain region is plainly attributable to the proximity of the Gulf coast only a few hundred miles to the south, whence characteristic forms no doubt migrate with more or less frequency up the streams or through the low mountain valleys, — while the high mountain ranges present many Alleghanian and even some Canadian forms. These conditions of life-zones normally opposed to

one another being brought so closely together in the southern part of our mountain section, render it a region of peculiar biological interest.

With regard to this southwestern section of our state, we cannot do better than to quote from an article on "An Ornithological Reconnaissance of Western North Carolina" by Wm. Brewster, published in "The Auk," January, 1886. He says:

> " . . . I have left a valley where Mocking-birds, Bewick's Wrens, and Cardinals were singing in water-oaks, sweet-gums and magnolias (all upper austral birds and plants), climbed a mountain side covered with oaks and hickories inhabited by Wilson's Thrushes, Yellow-throated Vireos and Rose-breasted Gross-beaks (Alleghanian forms), and within an hour or two from the time of starting found myself in a dense spruce forest where Winter Wrens, Golden-crested Kinglets and Red-bellied Nuthatches (Canadian forms) were the most abundant and characteristic birds. Indeed, were it possible in the present state of our knowledge to indicate accurately on the map the relative extent and position of the three faunae (life-zones) by using a different color for each . . . the work when completed would certainly present a strangely patched appearance.
>
> "The boundaries of these divisions are determined chiefly by elevation, the Canadian occupying the tops and upper slopes of the mountains down to about 4,500 ft., the Alleghanian the mountain sides, higher valleys, and plateaus between 4,500 and 2,500 ft., and the Carolinian (upper austral) everything below the altitude last named."

The authors in preparing this map have chosen to be conservative in representing the Alleghanian and Canadian zones, and there is doubtless more territorry actually included in each of these than the map shows. Furthermore, the extreme northwest counties are as yet practically unknown from a zoological standpoint, so that,—while we might assign most of its territory on hypothetical reasoning, we have preferred to leave it unmarked save by an interrogation point.

RALEIGH, N. C.

A BACTERIOLOGIC STUDY OF THE BLANK CARTRIDGE*

DAVID H. DOLLY

It appears from statistics in The Journal of the American Medical Association, August 29, 1903, that of 392 cases of tetanus incident to accidents on the previous July 4, 363 followed wounds from the blank cartridge and toy pistol. In other words, 92 per cent. of the tetanus cases were apparently attributable to wounds from blank cartridges.

Dr. A. I. Ludlow, assistant resident surgeon at the Lakeside Hospital, succeeded in isolating *B. tetani* from the blank cartridge wounds in one out of five fatal cases of tetanus, but cultivated the *B. aerogenes capsulatus* in four. In none of these cases was there emphysema nor emphysematous gangrene of the wounds, which were routinely treated by free incision and packing with iodoform gauze. In one of these which came to autopsy I failed to isolate *B. tetani* from the wound of the hand, but obtained *B. aerogenes capsulatus* from the local lesion and heart's blood. There was no gaseous emphysema of any organ.

These findings led me to investigate several makes of blank cartridges, and the results of these investigations form the basis of the present paper. The infectious agents concerned in these wounds (apart from the contents of the cartridge), may come from the skin and parts of clothing introduced. These latter sources of infection were not considered.

SOURCE OF MATERIAL

The cartridges used were manufactured by the Peters Cartridge Co., the Winchester Arms Co., and the Union Metallic Cartridge Co., and were bought in the open market at various times and places.

---

*Reprinted from *The Journal of the American Medical Association,* Feb. 11, 1905.

CULTURAL EXPERIMENTS

(*A*) *Wads.*—In both the cultural and animal experiments the wads were extracted with a sterile instrument, every care being taken to exclude accidental contamination.

The wads were placed in a 1 per cent. glucose bouillon, and incubated under anaërobic conditions (usually in Novy jars) at body temperature, for from 3 to 5 days, when coverslip preparations were studied. Not infrequently slender bacilli with end spores suggestive of *B. tetani* were seen. Nine cultures containing these tetanus-like bacilli were inoculated in fresh hematoma in the thigh of guinea-pigs. All of these animals survived but one, which died at the end of the month without symptoms of tetanus. These tetanus-like bacilli decolorized by Gram and were proved by cultural methods to be identical with a pseudo-tetanus bacillus discovered by Bain in blank cartridges. Many cultures contained a stout bacillus with square ends, apparently encapsulated, and subcultures made on glucose agar showed abundant gas formation. Nine rabbits injected with these gas-forming cultures, and killed ten minutes afterward, showed after from 8 to 20 hours' incubation marked gaseous emphysema, and *B. aerogenes capsulatus* was isolated from them all in pure culture. All efforts to demonstrate the presence of *B. tetani* failed. In a total of 250 wads examined by culture, the *B. aerogenes capsulatus* was demonstrated in sixty-six, or 26.4 per cent., and from sixty-one it was isolated in pure culture. Two of these were worked through all media, but in general the cultural characteristics on glucose agar, milk, and blood serum, together with the morphology, the capsule formation, the positive Gram stain, and the failure to grow aërobically, were deemed sufficient for identification. It is interesting to note that spore formation occurred in old milk and agar cultures, as well as on blood-serum. Some difficulty was experienced in separating *B. aerogenes capsulatus* from the other anaërobic organisms present in wads until Kitasato's method of heating for one hour at 80 degrees C. was adopted. It invariably survived this. That the explosion of cartridges neither kills nor inhibits the growth of *B. aerogenes capsulatus* was demonstrated by shooting the wads into jars containing melted glucose agar, which on incubation gave

abundant growth of this organism in four out of five experiments.

The following table gives the proportinn in which *B. aerogenes capsulatus* was found in wads of the different makes:

	Wads examined	B. A. C.	Per cent.
Peters .32 caliber..............	54	32	50.9
Peters .22 caliber..............	50	21	....
U. M. C. .32.................	49	7	7.0
U. M. C. .22.................	50	0	....
Winchester .22 caliber........	47	6	12.7
	250		

(*B*) *Powder*.—Cultures from the powder of 101 cartridges were usually serile. Neither *B. tetani* nor *B. aerogenes capsulatus* was isolated.

INOCULATION OF ANIMALS

At the suggestion of Prof. William H. Welch, the rat was used as being probably the animal most susceptible to tetanus.

To give *B. tetani*, if present, the most favorable environment possible, use was made of two procedures, the second one of which has not been employed in similar investigations. The first is inoculation of fresh hematoma, which increases greatly the chances of growth of *B. tetani*. As to the second one, Vaillard and Rouget established that "tetanus spores when free from toxin are innocuous when not accompanied by another bacterium, unless protected from phagocytes." . Twelve white rats were inoculated under strict asceptic precautions with wads from the Peters Co. 32 caliber cartridges. In addition, a loop of a pure aërobic culture was added, in six an attenuated *Staphylococcus pyogenes aureus* and in the remaining six *B. coli communis*. The skin was then closed by a stitch and covered with celloidin.

Nine of these rats died in convulsions, the tenth quietly, while the other two survived. The incubation period varied from sixty to seventy hours. The character of the convulsions differed from that usually described for animals. The first symptom was a marked spastic condition of the inoculated leg, which was held in extreme flexion, explained by the laceration of the extensor muscles. Gradually this spastic state extended to the whole body, so that the animal would retain its distorted shape in any position. In all, there was emprosthotonos, in two associated with pleurothotonos. The forelegs were held closely against the abdomen and the non-inoculated leg in extension. At short, ir-

regular intervals there were definite convulsions, the most typical of which started with several rapid nods of the head, followed in order by clonic spasms of forelegs and hindlegs, passing in a few seconds into a tonic spasm of the whole body. In several, clonic spasms alone appeared. The convulsions lasted from one and a half to three hours, the animals all dying at the end of a spasm.

At autopsy no lesions of internal organs were found. Smears from the meninges were negative for leucocytes and bacteria. Bearing in mind previous failures to cultivate *B. tetani* from wounds, it was thought wiser to subinoculate from these animals. Accordingly, the wads, with some necrotic tissue, were removed from six of the rats and inoculated into three guinea-pigs and three rabbits. The guinea pigs died during the night, but the rabbits developed tetanus in about thirty hours. The character of the convulsions corresponded to the description in text-books.

In smears from the rats and guinea-pigs, a few spore-bearing bacilli morphologically resembling *B. tetani* appeared. These were somewhat more numerous from the rabbits. From one rat only one such bacillus was seen after an hour's search. In all smears bacilli morphologically identical with *B. aerogenes capsulatus* were recognizable, together with numerous other organisms. Cultures were made from the wounds and wads on glucose bouillon and glucose agar, as well as blood serum. There was marked gas production, but repeated search failed to disclose *B. tetani*. Numerous subcultures, made both with and without Kitasato's method, were likewise negative. *B. aerogenes capsulatus* grew so rapidly and vigorously that it apparently crowded out *B. tetani* Many anaërobic plates were also unsuccessful as regards *B. tetani*. In explanation of these failures, it may be said that the tetanus-like bacilli were extremely scanty, while *B. aerogenes capsulatus* was relatively abundant; and, further, that several other bacilli were present in the Peters wad, which resisted heating as well, one of these forming colonies much resembling those of *B. tetani*.

However, of five rabbits inoculated with five or six loops of the original cultures, three died in convulsions. Smears and cultures from their wounds were also entirely negative for *B. tetani*, though made as soon as symptoms of tetanus appeared.

The experiment was next tried of adding several crystals of urea to the material inoculated for its antichemotactic effect. In this rabbit the exude was poor in leucocytes, and tetanus-like bacilli more numerous than in previous experiments, but *B. aerogenes capsulatus* had increased proportionately and several series of plates were again negative for *B. tetani.*

A second series of inoculations with the Peters wads was next made. Three rats and three guinea-pigs were each inoculated with two wads, together with *Staphylococcus pyogenes mucus*, and several small crystals of urea. One rat and two pigs developed tetanus. As in the previods experiments, tetanus-like bacilli appeared in greater numbers than in the first series, but have not yet been isolated.

Inoculation experiments were also tried with the other brands of cartridges. In the case of the Union Metallic cartridges, the wads from the seven original bouillon cultures which yielded *B. aerogenes capsulatus* were used. One rat died without tetanic symptoms, the others survived. Likewise, thirteen wads of the Winchester cartridges, distributed among three rats and three guiney-pigs, produced no symptoms, and the animals survived the local suppuration produced by the staphylococcus.

Previous work has been done on this subject by Le Garde, Taylor, Wells, and the Boston Health Department, a total of 759 cartridges having been examined, both by cultures and animal inoculations, all with negative results for *B. tetani*. The only report of the finding of *B. tetani* in cartridges is made by R. N. Connolly, bacteriologist to the board of health of Newark, N. J. He bases his diagnosis, apparently, on the morphology and odor of cultures, and no inoculation of animals is reported. With regard to *B. aerogenes capsulatus*, Wells alone describes an obligate anaërobe which corresponds closely to this organism, but says it seemed to have motility, and it is not identified.

My thanks are due to Dr. W. T. Howard, Jr., and to Dr. Roger G. Perkins, for their valuable suggestions.

CONCLUSIONS

1. *B. aerogenes capsulatus* (Welch) was present in a large proportion of the wads of the three makes of cartridges examined.

2. The wads of the Peters Company, inoculated in rats, guinea-pigs, and rabbits, produced characteristic symptoms of tetanus.

3. The powder of the three varieties of cartridges examined was negative for *B. tetani* and *B. aerogenes capsulatus*.

4. My efforts at isolation of *B. tetani* from the wads have so far been unsuccessful.

5. There is abundant evidence, from clinical observations and animal experiments, that the wads of certain blank cartridges contain *B. tetani*. Dr. Welsh told me that he considered it diagnostic to see an animal in convulsions.

REVIEW

The Chemistry of Commerce, R. K. Duncan. Harper & Bros., 1907. In this new book the author again, as in his "New Knowledge", translates admirably the technical and scientific facts into language easily understood by the layman. This he states to be his object, and he has succeeded well. The chief value of the book is not simply in the facts that are therein stated, nor in the description of the great industries dependent upon chemical science, but in the suggestions for improvement, in the inspiration to greater things, in the call to larger influence.

Although in the main the author does treat of the chemistry of commerce, yet in a few chapters the relation is somewhat far fetched. As an example, a chapter on "Floral Perfumes" treats for the most part on the methods used in obtaining the perfumes from flowers and only at the end records briefly the chemical production of artificial perfumes. Again in the chapter on "Making of Medicines", biology plays a more important part than chemistry. But if this is a fault, it may be largely overlooked because of the intensely interesting things therein recorded.

The author constantly points out the fact that Americans, while excelling in mechanical appliances are far behind in scientific knowledge concerning the basis of their industries, and hence the enormous waste through bye-products of factories. Finally he appeals to the manufacturer for a more scientific business, to the scientist for at least a toleration of research on technical problems, and the Universities to stand sponsor between the two.

The book is one that every manufacturer should read, to gain a knowledge of how the chemist may help him: it is one that every chemist should read to gain inspiration in his work.

R. O. E. D.

PAPERS RELATING TO SCIENCE

Published or read by the members of the Faculty of the University of North Carolina during 1907.

COLLIER COBB.

Notes on the Geology of Core Bank, N. C. Journal of the Elisha Mitchell Scientific Society, May, 1907.

The Garden, Field, and Forest of the Nation. Address as President of the North Carolina Academy of Science. Journal of the Elisha Mitchell Scientific Society, June 1907.

The Geological Work of the Atmosphere. Illustrated. Address at Guilford College, N. C.

WILLIAM C. COKER.

Fertilization and Embryogeny in Cephalotaxus Fortunei. Botanical Gazette, Oct. 1907.

Chapel Hill Ferns and Their Allies. Journal of the Elisha Mitchell Scientific Society, Nov. 1907.

A New Form of Achlya. Paper before the N. C. Academy of Science, May 1907.

ARCHIBALD HENDERSON.

Recent Investigations in the Foundations of Geometry. Paper before the N. C. Academy of Science, Chapel Hill, May 1907.

The Foundations of Geometry—An Historical Sketch. Journal of the Elisha Mitchell Scientific Society, May, 1907.

J. E. LATTA.

Notes on Motor Circuits. Electric Journal, Jan. 1907.

WILLIAM DEB. MACNIDER.

The Action of the Nitrites on the Heart. The American Journal of the Medical Sciences, Vol. 135, page 99.

A Further Study of the Action of Magnesium Sulphate on the Heart. American Journal of Physiology, Vol. 22, No. 11.

Some of the Later Manifestations of Syphilis with Report of Cases. Charlotte Medical Journal, September 1907.

J. E. MILLS.

A Review on "Researches on the Affinities of Elements," by Geoffrey Martin. Science, August 2nd, 1907.

Molecular Attraction VII. An Examination of Seven Esters. Journal of Physical Chemistry, Vol. 11, p. 594, 1907.

A. S. WHEELER.

Eine neue Farbenreaktion der Lignocellulosen. Ber. der deutsch. Chem. Ges., Vol. 40., p. 1888, 1907.

H. V. WILSON.

A New Method by which Sponges may be artificially reared. Science, Vol. 25, No. 649.

On Some Phenomena of Coalescence and Regeneration in Sponges. Journal of Experimental Zoology, Vol. 5, No. 2.

32

JOURNAL

OF THE

Elisha Mitchell Scientific Society

JUNE, 1908

VOL. XXIV NO. 2

ORNITHOLOGICAL WORK IN NORTH CAROLINA*

T. GILBERT PEARSON

Our earliest record of an ornithological observation in North Carolina is that of Captain Barlow who in company with his associate, Captain Amadas, visited the coast in 1584. Entering the Sounds by one of the inlets they sailed to Roanoke Island and landed. Evidently they climbed one of the tree-covered dunes girting the east side of the island, for Captain Barlow writes, "Under the bank or hill whereon we stood, we beheld valleys replenished with goodly cedar trees, and having discharged our barquebus shot, such a flock of cranes (the most part white) arose under us, with such a cry redoubled by many echoes, as if an army of men had shouted together." One visiting Roanoke Island today will still see goodly cedar trees but the herons, (which doubtless were the birds to which he referred) are no longer to be found in such numbers. Three hundred and twenty-five years of

*Presidential address before the North Carolina Academy of Science, May 1, 1908.

man's destructive influences have written their story large among the bird life of that interesting region, and the most northerly breeding colony of herons known to exist in the State is situated on an island in Matamusket Lake 45 miles away in a southwesterly direction. The birds here are so few in number, and their united cries would not equal the lusty shout of a corporal's guard.

Two years after this, viz.: in 1586, Thomas Hariot came to the island and made a list of the birds he found there. Of these he says there were "Turkey cocks and turkey hens, stock doves, partridges, cranes and herons, and in winter great store of swan and geese. Of all sorts of fowl, I have names in the country language, four score and six; of which number, besides those that he named, we have taken, eaten, and have the pictures as they were drawn, with names of the inhabitants; of several strange sorts of water fowl eight, and seventeen kinds more of land fowl, although we have seen and eaten many more which for want of leisure there for the purpose, could not be pictured; and after we are better furnished and stored upon further discovery with their strange beasts, fish, trees, plants and herbs, they shall be published. There are also parrots, falcons, and merlin-hawks, which although with us they be not used for meat, yet for other causes I thought good to mention."

One of the most interesting items in this narration is the reference to "parrots", which establishes the fact without doubt that the Carolina Paroquet at one time inhabited the immediate neighborhood of the coast.

John Lawson, Gentleman, in his History of North Carolina published in London in 1714, devotes fully ten pages to an enumeration of the birds of the state and a dissertation on the habits and activities of some of them. Many of the birds which he found here were new to him, and as he evidently was not a trained ornithologist he failed in many instances to note the difference between them and those species of Europe which to his eye they much resembled. To many of our native birds therefore he gave the names of English species, and his descriptions being meagre we are often left in doubt as to what birds he really had in mind. Thus what he calls "Moorehen" may have been either the Gallinule or

the coot. His "Lay-wing" was perhaps one of the plovers, the golden, black-bellied, Wilsons or piping, or may have been the dowitcher or turnstone.

Among the hawks he speaks of the "Hobbie". I am yet at a loss to understand to what species he referred as all the other small hawks are evidently accounted for under such English titles as Falcon, Merlin, etc.

He made the mistake of regarding the young Bald Eagle as a distinct species and calls it the gray eagle. This error, by the way, was long followed by subsequent observers of North American bird life. Audubon, writing over a hundred years later, tells in much detail about the life history of the gray eagle, in fact he has left us a full page drawing of the magnificent "Bird of Washington", as he calls it. The fact that the young bald eagle does not acquire its white head and tail until after an elapse of three years will account in a measure at least for its mistaken identity.

On the other hand some of Lawson's statements which bear on the face evidences of being perfectly truthful, reveal some valuable information. One of these is his account of the breeding of the black duck in the eastern marshes and another which tells of the common occurrence of the sand hill crane. These are the only two positive records we have of this character within the borders of North Carolina, for so far as known no one else has recorded cranes in the state, and while the black duck is a common winter visitor and has long been suspected of breeding here, we know of no authoritative record of a nest having been found since this account given by Lawson.

In the days of Lawson the wild pigeon which has since become extinct, was an aboundant bird in North Carolina. They probably gathered to breed in vast numbers in the mountains, after which they spread over the low country and their numbers being augmented by great flights from the north, the pigeon population must have been something enormous. Lawson says "I saw such prodigious flocks of these pigeons in January and February, 1701-2 (which were in the hilly country between the great nation of the Esaw Indians and the pleasant stream of Sapona, which is the west branch of Clarendon, or Cape Fear River, that

they had broke down the limbs of a great many large trees all over those woods, whereon they chanced to sit and roost; especially the great pines which are more brittle wood, than our sots of Oak are. These Pigeons, about sunrise, when we were preparing to march on our journey, would fly by us in such vast flocks that they would be near a quarter of an hour before they were all passed by, and as soon as that flock was passed another would come, and so successively one after another for a greater part of the morning. It is observable that wherever these fowls come in such large numbers, as I saw them then, they clear all before them, scarce leaving one acorn upon the ground, which would doubtless be a great prejudice to the planters that would seat there, because their swine would be thereby deprived of the mast. When I saw such flocks of the Pigeons I now speak of, none of our company had any other sort of a shot than that which is cast in moulds and was so very large that we could not put above ten or a dozen of them into our largest pieces. Wherefore we made but an indifferent hand of shooting them; although we commonly killed a Pigeon for every shot. They were very fat and as good Pigeons as ever I eat."

While it can hardly be claimed that the writings of John Lawson are of any great ornithological value, they are at least interesting from a historical standpoint and should most assuredly be included in any bibliographical sketch of North Carolina ornithological study.

The work of Col. Wm. Byrd of Westover, Va., next claims our attention. It was he who conducted the survey of the boundary line between ———, Va., and North Carolina in 1729. The narrative of his experiences which we are told was written largely for his own amusement and that of his friends, contains besides an account of the survey many side remarks on the inhabitants of the territory which he traversed. His references to natural history are not infrequent, but are for the main part of little moment. The following contribution on the habits of the Carolina paroquet, a bird now extinct, may be of interest. "Very few in this country have the industry to plant orchards, which in a dearth of rum might supply them with much better liquor. The truth is there is one inconvenience that easily discourages lazy people

from making this improvement. Very often in autumn when the apples begin to ripen they are visited with numerous flights of paroquets, that bite all the fruit to pieces in a moment for the sake of the kernels. The havoc they make is sometimes so great that sometimes whole orchards are laid waste in spite of all the noises that can be made or mawkins that can be dressed up to frighten them away. These ravenous birds visit North Carolina only during the warm season and so soon as the cold begins to come on retire back towards the sun. They rarely venture so far north as Virginia except in a very hot summer, when they visit the most southern parts of it. They are very beautiful, but like some other pretty creatures are apt to be loud and mischievous.'' He does not attempt to catalog the birds of the country.

In the library of the State College at Columbia, S. C., I recently found that rare and interesting work of Catesby ''The Natural History of Carolina, Florida and the Bahama Islands,'' published in 1731. A careful reading of its pages, however, reveals the fact that the author in all probability was never within the borders of North Carolina. He went up the Savannah river almost to the mountains and hunted buffalo with the Indians; later he sailed for Virginia, and ascending the James river, traveled thence westward to a point almost north of that reached on his trip from Savannah. There seems to be no evidence that he ever saw the intervening territory. This is to be regretted, as Catesby was not only an artist of merit but for the times must have been a very careful and painstaking naturalist. I mention this work because its title would lead one to think he had made a study of the Natural History of this state.

In my quest for information regarding early ornithological writers I applied to North Carolina's most noted historian of today, Dr. Stephen B. Weeks, and from him received many courtesies including the loan of some of the books from his extensive library. One of these is the work of Dr. John Brickell published in Dublin in 1737, and bearing a comprehensive title as follows: ''The Natural History of North Carolina, with an account of the trade, manners, and customs of the Christian and Indian inhabitants; illustrated with copper plates, whereon are curiously engraved the map

of the country, several strange beasts, birds, fishes, snakes, insects, trees and plants, etc."

His list of birds follows closely that of Lawson published some years previously, and the similarity of the text in many instances strongly suggests the idea that he frequently bordered closely on plagiarism.

He enumerates 129 kinds of birds. Five of these at least we must eliminate at the start. He makes three eagles out of one, naming as he does in addition to the bald eagle the black and gray eagles which are simply different phases of the immature bird. We, of course, cannot accept two species of leather-winged bats for birds, and the nightingale which he mentions is not found in a wild state in the Western Hemisphere.

Although Dr. Brickell in his Preface says regarding his Natural History writing "I have been very exact," the reader is not always so impressed. Of the brown pelicans he says "They have an odd kind of note much like the braying of an ass, and in spring they go into the woods to breed and return in the autumn." Whereas it is a well-known fact that the pelican is an absolutely silent bird and breeds on the ocean beaches or on mangrove Keys of the Gulf coast. Of the cuckoo he writes "In winter they hide themselves in hollow trees, and their feathers come off, and they are scabby, they usually lay one egg, and that in the nest of the Hedge Sparrow."

This reminds one of the story of the Naturalist Humbolt to whom a student stated that a lobster was a red fish which runs backwards. Humbolt is reported to have replied "You are right in all but three things, viz: it is not red, it is not a fish and does not run backwards." The Carolina cuckoos do not hide in hollow trees, they do not lose all their feathers at once and become scabby, they lay not one but from two to four eggs in a nest of their own construction, and finally the hedge sparrow is not found in America.

In treating of the gray eagle he discusses at considerable length its interesting characteristics of form and activities. In part he says "They are great thieves, and live to be very old and die not from age nor any sickness, but of mere hunger by reason that the

upper beak of their bill is so far over grown and turneth inward so much, that they are not able to open it to feed themselves. They seldom seek their prey in the forenoon, for they are found sitting idle and perched upon trees all the morning. It is reported that the quills or feathers of eagles laid amongst those of other fowls will rot and consume them, which I have not faith to believe. The flesh though scarce fit to be eaten is medicinal against the gout, the bones of the skull in powder are good against megrim, the brain drank in wine, helps the jaundice, and the gaul is of excellent use in most disorders of the eye, and applied helps the bitings of serpents and scorpions, etc.

Delicious as Brickell's natural history sketches are, it is almost certain that he acquired much of his material from the Indians and settlers and has woven into his narrative many of the traditions and superstitions of the country. Positive statements as to what he actually saw occur but seldom, one of these is when in speaking of the smallness of the hummingbird he remarks "I have frequently seen butterflies chase them away from the flowers." The butterfly of his day must have been a pretty formidable creature.

Another of these early gentlemen who traveled through the South and left his writings for the benefit of posterity was Wm. Bartram in 1791. His book is entitled "Travels through N. C. S. C., Fla., etc." It seems, however, that he made but one hasty trip through North Carolina. He traveled by land. Entering the State in Brunswick county, he proceeded to Southport, passed from there up the Clarendon (or Cape Fear river) to Cambletown (now Fayetteville), and thence on to Virginia. He speaks briefly of the trees, soil and rocks, but makes no reference to the wild animal life. Some of his stories are very lightly colored. He speaks of the alligators of S. C., rushing at him with terrible roarings and with steam rushing from their mouths and nostrils which threw over him a hurricane of water. In reading his writings one is inclined to believe that William Bartram would come under the class of President Roosevelt's "Nature Faikirs."

Apparently the first real ornithologist to visit North Carolina for the purpose of studying the birds was Alexander Wilson, a Scotch-

man who traveled through the country collecting birds and making drawings of them by day and playing the violin for profit or diversion at night. Wilson was a field naturalist of the first order, and his great work "American Ornithology" illustrated in colors with his own most creditable drawings in colors has well won for him the title of "Father of American Ornithology," despite the fact that his work was eclipsed some years later by the stupendous undertaking of Audubon. As an ornithologist Audubon was Wilson's superior only in that he was a more skilful artist. As a man Wilson was of humble parentage, but indifferently educated, was poor, retiring, sensitive and self-effacing. Audubon was of excellent parentage, was highly educated, was always confident and at times self-assertive. Both were great contributors to the world's knowledge of American birds, and it was their work which aroused real interest in the subject and put in motion the movement for bird study from which has since developed a long line of brilliant American naturalists.

On one of Wilson's trips through North Carolina, he found a specimen of the largest of all American wood-peckers, the Ivory-billed. The bird has long been extinct in this State. Another point of interest attending this capture by Wilson is that there is no record of one ever having been taken farther north in Eastern America. His record is therefore interesting and unique. He says, "The first place I observed this bird at, when on my way to the south, was about twelve miles north of Wilmington in North Carolina. There I found the bird from which the drawing of the figure in the plate was taken. This bird was only wounded slightly in the wing, and, on being caught, uttered a loudly reiterated, and most piteous note, exactly resembling the violent crying of a young child; which terrified my horse so, as nearly to have cost me my life. It was distressing to hear it. I carried it with me in the chair, under cover, to Wilmington. In passing through the streets its affecting cries surprised every one within hearing, particularly the females, who hurried to the doors and windows with looks of alarm and anxiety. I drove on, and on arriving at the piazza of the hotel, where I intended to put up, the landlord came forward, and a number of other persons who

happened to be there, all equally alarmed at what they heard; this was greatly increased by my asking, whether he could furnish me with accommodation for myself and my baby. The man looked blank and foolish, while the others stared with still greater astonishment. After diverting myself for a minute or two at their expense, I drew mp woodpecker from under the cover, and a general laugh took place. I took him up stairs and locked him up in my room, while I went to see my horse taken care of. In less than an hour I returned, and, on opening the door, he set up the same distressing shout, which now appeared to proceed from grief that he had been discovered in his attempts to escape. He had mounted along the side of the window, nearly as high as the ceiling, a little below which he had begun to break through. The bed was covered with large pieces of plaster; the lath was exposed for at least fifteen inches square, and a hole, large enough to admit the fist, opened to the weatherboards; so that, in less than another hour he would certainly have succeeded in making his way through. I now tied a string around his leg, and, fastening it to the table, again left him. I wished to preserve his life, and had gone off in search of suitable food for him. As I reascended the stairs, I heard him again hard at work, and on entering had the mortification to perceive that he had almost entirely ruined the mahogany table to which he was fastened, and on which he had wreaked his whole vengeance. While engaged in taking the drawing, he cut me severely in several places, and, on the whole, displayed such a noble and unconquerable spirit, that I was frequently tempted to restore him to his native woods. He lived with me nearly three days, but refused all sustenance, and I witnessed his death with regret." The above account refers to a great woodpecker nearly as large as a crow and now confined to the more inaccessible swamps of the Gulf coast.

What we may term recent ornithological research began in North Carolina in 1871, when Dr. Eliott Coues published in the Proc. Acad. Nat. Sci., Philadelphia, May 2, a series of notes on the birds observed by him while stationed at Fort Macon in Carteret county, 122 species of birds were mentioned.

In 1886, William Brewster of Cambridge spent some time in the

mountains of western North Carolina, and his list of birds published in the "Auk" contains records of 120 species. The preceding winter Charles Bachelder, also of Cambridge, made a number of observations on the winter bird life of the mountains and this likewise was published in the "Auk." One of the discoveries made by Mr. Brewster was the Carolina snow bird (Junco hyemalis Carolinensis). J. S. Cairns, an enthusiastic student of birds living at Waynesville, published the results of his observations in the "Ornithologist & Oologist" in 1887. He enumerates 169 varieties of birds in Buncombe County. It was he who first discovered the Cairns Warbler.

Messrs. H. H. & C. S. Brimley, of Raleigh, were for many years engaged in collecting birds for scientific purposes. During this time and since they have gathered much valuable information on the nesting and migration habits of the birds which occur there. Between 1884 and 1891 they published in the "Ornithologist & Oologist" 76 articles on Raleigh Bird Life. Mr. R. B. McLaughtin during 1887-1888 contributed 9 articles to the same publication on the birds of the Statesville region.

Additional papers on the bird life of the state to the extent of 47 in number by various authors have been published; principally in the "Auk" and the "Ornithologist & Oologist."

Thus briefly and somewhat hastily I have attempted to sketch what has been done in the line of ornithological study in North Carolina. It will be observed that the work done has been mostly in gathering notes on the geographical distribution, migration and modification of the species found in the state. Considerable attention has also been paid to Oology by Messrs. Brimley of Raleigh, McLaughtin of Statesville, Joseph Armfield of Greensboro (whose splendid collection of eggs of our native birds may be seen at the Museum of this College), Dr. Smithwick of Arora and a few others.

Today we know of positive records of 325 species of birds which have been taken in the state, some of these at least are exceedingly rare and may be regarded only as stragglers. Among these may be mentioned the Northern Phalerope taken by Dr. Bishop at Pea Island; the Ruff taken at Raleigh by Mr. Brimley; the

Black-necked Stilt captured at Roanoke Island by the Rev. Mr. Moyle; the bay-breasted Warbler noted at Chapel Hill and the Man-o'-war bird secured at Ocracoke by the speaker.

It may not be out of place here to mention that the state Audubon Society has in preparation a book on the birds of the state and a note regarding any rare finds made by members of the Academy will be greatly appreciated. In conclusion it has occurred to me that it might not be out of place to present to the Academy some views illustrating game preserve activities in the state also showing what the Audubon Society has been able to accomplish in one small island in the way of protecting sea birds.

Greensboro, N. C.

PROCEEDINGS OF THE NORTH CAROLINA ACADEMY OF SCIENCE

The North Carolina Academy of Science held its seventh annual meeting at the State Normal College, Greensboro, N. C., on Friday and Saturday, May 1 and 2, 1908.

The Academy was called to order at 3:30 P. M., May 1, by the president, T. Gilbert Pearson. A letter of welcome to the academy from President J. I. Foust of the College was read. A response to this welcome was made by the retiring president, Collier Cobb, of the Academy.

At 8:30 in the evening the Academy met in the auditorium of the Students' Building, and the presidential address, "An Historical Sketch of Ornithology in North Carolina" (illustrated by lantern slides)* was delivered by President T. Gilbert Pearson. Following this address a reception was tendered the members of the Academy by the faculty and students of the senior and junior classes of the College in the dining room of Spencer Building. Later President and Mrs. Pearson received the visiting members at their home on West Market Street.

At 9 A. M. Saturday, May 2, the Academy convened for a business meeting. Reports of various committees were heard. The report of the treasurer showed a balance of $119.60.

The following new members were elected: Mr. Harry N. Eaton, Instructor in Geology, and Mr. Hubert Hill, Assistant in Geology, University of N. C.; Mr. R. I. Smith, Entomologist to the N. C. Experiment Station, West Raleigh; Mr. S. B. Shaw, Assistant Horticulturist N. C. Department of Agriculture; Dr. L. L. Hendron, Professor of Applied Mathematics, Trinity College, Durham, N. C.; John Roy Williams, M.D., Greensboro; Mrs. Charles D. McIver, State Normal College, Greensboro.

*This address appears in full in this issue of the Journal.

The following officers were chosen for the ensuing year:

President, Tait Butler, Department of Agriculture, Raleigh.

Vice-President, J. J. Wolfe, Trinity College, Durham.

Secretary-Treasurer, E. W. Gudger, State Normal College, Greensboro.

Executive Committee, Chas. H. Herty, University of N. C., Chapel Hill; John F. Lanneau, Wake Forest College, Wake Forest; W. H. Pegram, Trinity College, Durham.

The Committee on Resolutions brought in the following report, which was unanimously adopted:

> In pursuance of the duties devolving upon the committee appointed, the committee begs to submit the following resolutions:
>
> (1) That in the death of Prof. J. W. Gore, Dean of the Department of Applied Science and Professor of Physics at the University of North Carolina, the North Carolina Academy of Science feels that it has suffered profound loss,—the loss of an investigator whose scientific attainments were notable, a scholar whose interest in scientific progress, in general as well as in his own and allied subjects, was unbounded, and a man whose broad humanity and high Christian character were a source of inspiration to all with whom he came in contact.
>
> (2) That a copy of these resolutions be published in the official organ of the Academy and likewise in the public press.

The next meeting of the Academy will be held at Trinity College, Durham, N. C., May, 1909.

The following papers were presented:

The Amanitas of the Asheville Plateau, by H. C. Beardslee, of Asheville, N. C.

The following list of species was reported:

Amanita Caesarea Scop., A. virosa, A. Phalloides Fr., A. muscaria Linn., A. pantherina DC., A. junquillea Quel., A. strobiliformis Paul., A. solitaria Bul., A. schinocephala Vitt., A. rubes-

cens, A. cinerea Bres., A. nitida Fr., A. vaginata Fr., A. volvata Pk., A. farinosa Schw., A. mappa Fr.

The species A. verna, virosa, and phalloides were considered as not distinct.

Amanita junquillea Quel. was illustrated by photographs and specimens and compared with the European forms. The Americac A. russuloides Pk. was referred here, also the European species A. amici, adnata, and vernalis. Photographs and specimens had been seen by Bresadola and Boudier who verify this conclusion. Specimens of the European form had also been examined.

Amanita cinerea Bres. was shown to include A. spreta Pk.

A. volvata was shown to be the plant referred by Quelet and Bataille to A. coccola Scop. It was also considered the true A. agglutinata of Curtis, and A. baccata as understood by Bresadola.

Photographs of many forms of A. solitaria and its allies were shown illustrating the difficulty of successfully defining species in this much confused group.

Distribution and Migration of Warblers at Raleigh. C. S. Brimley of Raleigh, N. C.

An Adjustable Armellary Sphere—Newly Designed, J. F. Lanneau, of Wake Forest College, N. C.

This paper dealt with a unique piece of apparatus—a light, symmetrical mechanism, built by Wm. Gaertner & Co., Chicago, after Professor Lanneau's design—for class-room use in Wake Forest College.

Its special feature is the placing of the horizon plane and vertical circles *within* the celestial circles, and the two concentric systems, mechanically *independent*, allowing of the real eastward rotation of the former, or of the apparent westward rotation of the latter.

SOME ILLUSTRATIONS.

1. An alluminum ball at the centre represents the sun; and by a simple device a smaller ball revolves around it eastward in the plane of the ecliptic, representing the earth's annual motion.

2. With central ball representing the earth, to it is securely attached the horizon plane and vertical circles for, say, an observer in latitude 36° north. Clamping the celestial circles in fixed position, the earth-ball with its horizon system is easily rotated eastward, showing sun-rise and sun-set and the rising and setting of moon, stars and planets—these objects being suitably indicated, for any given date, in their apparent places on the celestial frame-works. Or clamping the horizon in its seemingly fixed position, the celestial circles and objects in place are readily rotated westward in accord with familiar appearances.

3. Altering in latitude the attachment of the horizon plane to the earth-ball, the apparatus shows in turn the reality and the appearances to an observer at the equator; or, again, to an observer at the north pole during his six-months' day and his six-months' night.

4. Some circles and the celestial objects may be variously adjusted and placed for an indefinite number of of astronomical illustrations.

5. Selected circles and objects may be duly disposed to facilitate apprehension and solution of numerous celestial problems – and, if problems also in geodesy and navigation which involve the ever-recurring "astronomical triangle".

QUESTION AND ANSWER.

Are the earth and sun at the centre? They are not held to be at the centre of the myriad stars of the visible universe. They are at the centre of the "celestial sphere", conceived of as everywhere equidistant from the earth; so distant as to be beyond the remotest star. Its quasi reality is that vast shell of void space beyond the stars, upon which as a dark, spherical background all the stars appear fixed as viewed from the central earth. So measureless its remoteness, any point within the earth's comparatively little orbit, including the sun, is virtually its centre.

This "celestial sphere", with sun or earth as centre, is the basis of practical astronomy. Its standard circles in miniature are part of our armillary sphere.

Concerning Sclerotinose of Lettuce, F. L. Stevens and J. G. Hall, of the N. C. Experiment Station, Raleigh.

The term *Sclerotinose* was proposed as a designation for diseases caused by *Sclerotinia*, and Sclerotinose of lettuce was characterized as one form of lettuce drop caused by *S. Libertiana*.

As the result of two years' study the authors conclude that the only part of the fungus that lives through the quiescent period of the disease is the sclerotium and that each season's infection is by wind borne ascospores produced from these sclerotia. They recommend that the formation of sclerotia be prevented by early removal and destruction (incineration or burial) of infected plants. This course followed for a few years, accompanied by the exhaustion of all sclerotia originally in the soils by germination, seems promising as a means of ridding infected regions of the pest.

The Origin of Certain Topographic Features along the Sand-Hills Border of the Atlantic Coastal Plain. Collier Cobb, of the University of North Carolina.

*Notes on the Life-zones in North Carolina.** By C. S. Brimley and Franklin Sherman, Jr., Raleigh, N. C.

The authors, having made a careful detailed study of all available records of the occurrence and distribution of animals in the state, present their conclusions as to the probable boundaries of the different life-zones. The groups of animals chiefly relied upon are: Mammals, Reptiles, and Batrachians. Birds and insects have been used mainly to confirm ideas otherwise originated.

It is found that four distinct life-zones are represented in the state as follows:

1. *The Canadian Zone*, including only the tops of the higher mountains, usually above 4,500 feet elevation. The following places are placed in this zone: Black Mountains, Roan Mountain, Grandfather Mountain, Bald Mountain in Yancey County, and the higher mountains in Macon County near Highlands.

*This paper was published in full in this Journal, for May, 1908.

2. *The Alleghanian Zone*, includes practically all between the elevation of 2,500 ft. and 4,500 ft. This includes most of the Blue Ridge and Smoky Mountains, Nantahala Mountains, Balsam, Pisgah Ridge and the lower elevations of Black Mountains and others mentioned as belonging to the Canadian zone.

3. *The Upper Austral Zone* includes all of the state north and west of a line drawn from Suffolk, Va. to Raleigh, thence to Charlott•, thence to the South Carolina line near Tryon in Polk County—except that portion already assigned to the Canadian and Alleghanian zones.

4. *The Lower Austral Zone* includes all of the state to the south and east of the line just mentioned.

Lists are given of the characteristic animals in each of these zones, and mention is made of a number of exceptional records, where animals have been taken beyond the limits of what their range would supposedly be.

The counties in the extreme northwest part of the state have not yet been zoologically explored, and are therefore not yet assigned to any zone, awaiting the accumulation of more records.

The Relation of Bovine Tuberculosis to the Public Health. Tait Butler of the Dept. of Agriculture, Raleigh.

"*The Twenty-Seven Lines Upon a Cubic Surface.*" Archibald Henderson of the University of North Carolina.

In his paper, Dr. Henderson explained that by the selection of a highly symmetrical equation of a cubic surface:

$$\left(\frac{x}{x_2}+\frac{y}{y_2}+\frac{z}{z_2}+\frac{w}{w_2}\right)\left(\frac{xz}{x_1z_1}-\frac{yw}{y_1w_1}\right)$$

$$-\left(\frac{x}{x_1}+\frac{y}{y_1}+\frac{z}{z_1}+\frac{w}{w_1}\right)\left(\frac{xz}{x_2z_2}-\frac{yw}{y_2w_2}\right)=0$$

by a proper choice of constants x_1, y_1, z_1, w_1; x_2, y_2, z_2, w_2; and finally by employing a regular tetrahedron of reference, that it was not difficult to derive very simple and symmetrical equations of the twenty-seven lines upon the cubic surface, and therefore to

construct a string model of the configuration, showing the fundamental tetrahedron and the twenty-seven lines in proper relation to each other and to the fundamental tetrahedron. Instead of a string or wire model, he exhibited a beautiful perspective drawing in colors, of the configuration.

The Scope and Function of Science. Wm. Louis Poteat of Wake Forest College. [Read by title.]

Some Trials of a Museum Curator. H. H. Brimley, State Museum, Raleigh. [Read by title.]

The Oral Gestation of the Gaff Topsail Catfish, Felichthys marinus. E. W. Gudger of the State Normal and Industrial College.

This paper was given by permission of the Commissioner of Fisheries and will later be published in the Bulletin of the Bureau.

The Proximate Constituents of the Oleoresins of Pinus palustris and Pinus heterophylla. Chas. H. Herty of the University of North Carolina.

*The San Jose' Scale.** By Franklin Sherman, Jr., Entomologist N. C. Dept. Agriculture, Raleigh.

The paper opens with an apology and explanation for presenting a paper upon so threadbare a subject before the Academy, — stating however, the author's belief that popular presentation of subjects of economic interest to the state should have a conspicuous place on the program.

A brief account of the history and general distribution of the San José Scale (Aspidiotus perniciosus, Comst.) is given, and mention is made of the principal food-plants, and methods of spread.

Referring to conditions within the state of North Carolina it is shown that present records indicate the pest in 65 counties, at 145 different post-office localities and on at least 423 different premises. It is a *safe presumption* that it is in many localities in addition to those on record. It is a *reasonable presumption* that it is

---

*This paper appears in full in this issue of the Journal.

in every county in the state but it *cannot be presumed* that it is in every locality, —and there is every reason to believe that many individual premises are not yet infested by it.

In at least seventeen communities it is generally distributed, having been found in a number of orchards or perhaps in all. In the west, it is known in the counties of Cherokee, Haywood, Mitchell and Watauga, —and in the east in the counties of Brunswick, New Hanover, Carteret and Pasquotank. It is found only a few feet above sea-level, and at an elevation of 4,000 ft.

According to present records the worst-infested counties are as follows in order of infestation: Catawba, Surry, Guilford, Moore, Gaston, Wake and Polk.

Concerning the Difference of Behavior of Soil Organisms When in Solution and When in Soils. F. L. Stevens and W. A. Withers of the N. C. Experiment Station, Raleigh.

(A prelimiminary Report of work done by F. L. Stevens and W. A. Withers assisted by W. A. Syme and J. C. Temple.)

Results of numerous experiments were adduced to show that the activities of ammonifying, nitrifying, denitrifying and nitrogen gathering bacteria are different in soils from what they are in solutions and that no adequate knowledge of the efficiency of these various soil organisms in effecting chemical change can be attained by tests conducted in solutions. Even the relative powers of different organisms or of different soils is largely affected by the conditions of the test. It seems therefore that in the study of soil bacteria the work must be done with soils, rather than with solutions or at least that frequent controls or checks in soil must be made.

THE SAN JOSÉ SCALE

A Brief Popular Account of a Notorious Insect Pest, with a Statement of its Present Recorded Status in North Carolina*

BY FRANKLIN SHERMAN, JR.

About three years ago, two prominent amateur collectors of insects, each an authority in his chosen group, were in this state on a brief collecting trip, and, by arrangement, I met them and spent a day in their company. It chanced that the orchards throughout all that neighborhood (Southern Pines) are infested with the San José Scale, and when I mentioned this fact quite incidently, both immediately expressed great interest and desire to see the pest, saying that they had often heard of it but had never seen it or received any first-hand information concerning it. Yet this insect is so notorious a pest, that among economic entomologists the discussion of it is now almost debarred, by mutual consent and unwritten law, from the public meetings. One year ago, at the sixth annual meeting of our Academy at Chapel Hill, Dr. Butler gave a discussion of the Cattle Tick, a pest of wide distribution and of tremendous economic importance to the live-stock interests of the southern states, and while none of the facts which he gave could in any wise be regarded as new and original contributions to science, yet the paper was received with manifest interest by our Academy.

These facts have convinced me that however desirable it may be to present at our meetings the results of really new and original

*Read before the North Carolina Academy of Science, May 2, 1908.

research, one of our most beneficent functions will be missed if we fail at the same time to have on our programs a certain number of popular discussions of matters of economic importance to our state.

So much by way of apology for discussing before this body a subject which to economic entomologists at least, has become threadbare and almost barren of new thoughts.

* * *

The *San José Scale* (Aspidiotus perniciosus) was first described to science in 1880 by Prof. J. H. Comstock, who found it very destructive in deciduous fruit orchards in the Santa Clara valley of California. He recognized it as one of the so-called "Scale-insects", belonging to the genus *Aspidiotus*, remarking that it was the most pernicious scale-insect known to him, and therefore applying to it the specific name of *perniciosus*, and proposed that it be called the Perniciosus Scale. But as the city of San José is not distant from the place where it was discovered it became known by the popular designation of The San José Scale.

There is reason to believe that it became established in California as early as 1870, and there is reason also to believe that it was introduced into California from China, which seems to have been its original home.

In the eastern United States the insect was not known until 1893 (only fifteen years ago) when it was discovered at Charlottesville, Va. on trees which had been purchased from New Jersey nurseries and these nurseries had presumably become infested by the importation of stock from California. Only four or five years later it was known to exist in twenty states east of the Mississippi river. It is not to be supposed that Charlottesville, and the New Jersey nurseries, were the only sources of scale in the east. It is likely that it became established in many other localities and perhaps in other nurseries at about the same time.

So far as we know the San José Scale gained its first foot-hold in North Carolina at or near Southern Pines, Moore County, about 1893 or 1894, approximately at the same time that it was discovered at Charlottesville. It was not recognized until 1895 at

which time it had gained a strong foothold. In 1897 it was known in six or eight localities, In 1900 it was known in about twenty places. In August 1904, it was known in 44 counties. At present (April 1908) it is known to be on no less than 423 different premises, at 145 different post offices (or rural routes therefrom), in 65 counties. Further details of its present known distribution in this state will be discussed later.

Trees that are very badly infested with the San José Scale look as if they had been dusted over with ashes. Examined with a lens this scurfy crust on the branches is found to be made up of hundreds of little nipple-like objects or scales, lying close to the bark. The largest scales are those of the mature females and are gray in color, circular, about the size of the head of a good-sized pin but with a slightly greater degree of convexity than the surface of the top of the pin-head. Slightly to one side of the center of the scale is a lemon-yellow nipple or "center". Turning over this scale with a pin or knife-point we may find the bright yellow, soft-bodied, wingless, eyeless, legless body of the female insect beneath. Indeed, her energies seem concentrated on the two all-important biological functions of assimilating food and reproduction. The food is procured by means of a slender thread-like organ thrust into the bark and through which the sap of the tree is imbibed.

The young are born alive, there being no distinct egg-stage in the life-history of the species, and the young are able to creep out from under the parent scale. For a few hours these yellowish young lice, barely visible to the naked eye, are able to creep about freely, but when they are compelled by hunger to thrust their beaks into the bark to draw nourishment they become permanently attached, and after a few hours more the scale begins to form, being composed of a waxy secretion from the body, combined with the cast skins of the growing young insect.

There are a number of complete and distinct generations of the insect in the course of the season, but when settled cold winter weather comes the old insects nearly always die, leaving only the partly-grown ones to survive. These over-wintering scales are almost black and about as large as the cross-section of the body of

a good-sized ordinary pin. When the growing season opens in the following spring the female develops as already described while the scale of the male becomes elongate and the creature finally develops into a tiny yellowish, winged, flying insect, which although mouthless and thus incapable of taking sap from the tree, is endowed with an extra set of eyes to make all the more certain of finding mates and providing for the perpetuation of his species.

We have said that the scales may be matted together in a scurfy coating over twigs and branches of badly-infested trees. In cases of slight infestation the scales may be scattering, only a few being found on a piece of twig, or perhaps even only one or two being found on an entire tree. Where the scales are scattering on the bark each scale is apt to be (but is not always) surrounded by a reddish blotch or spot. This reddish staining is very noticeable in the inner bark of badly infested twigs. It is also quite conspicuous on those varieties of trees which have a yellowish or greenish bark, in contrast to which the reddish blotches show up in bold relief.

We have stated that the insect after once settling down to feed remains attached at that spot. We have also seen that the female never emerges from under the shell or scale. The adult male, which can fly, can play but an unimportant part in the spread of the species. How, then is the species distributed? The several agéncies by which this is accomplished are:—1st, by its own natural powers, each young louse often crawling several inches from the parent scale before attaching itself, 2nd, by wind, which in blowing through an orchard may waft the tiny young like particles of dust or pollen from one tree to another, 3rd, by birds, which may alight in an infested tree and then rapidly transport young crawling lice on their feet or feathers to new trees, 4th, by insects, in same way as by birds, 5th, by man, horses, etc. in cultivating or working in the orchard and passing from tree to tree. All the above means facilitate its spread locally from tree to tree, or from one orchard to another in the same neighborhood. But for spread into new and distant localities the San José Scale is chiefly dependent on still another method, namely 6th,

the transportation of infested trees or plants. It is on account of this last feature of its spread that all of the eastern states have adopted measures providing for the the inspection of fruit-tree nurseries and the condemnation of stock found to be infested.

The San José Scale is not capable of living and thriving on all kinds of plants. For convenience its food-plants may be divided into three clases. First, the *ordinary food plants* on which it is most commonly found, and including peach, apple, plum, pear, cherry, and apricot. Second, the *not uncommon* food plants, including currant, gooseberry, rose, grape, osage-orange, thorn-apple, Japan walnut, Japanese (or flowering) quince, poplar, elm, and linden. Third, what we may call *the uncommon or rare food-plants* including persimmons, walnut, sumac, catalpa, willow, ash, dogwood, maple, spruce, cedar, raspberry, strawberry, milkweed, and even crabgrass.

In short, while it is found on a great variety, yet its economic aspect is principally concerned with its occurrence on our cultivated deciduous fruit plants, (especially orchard trees) and such ornamental plants as belong to the botanical family Rosaceae. Only in rare cases has it been found in the actual forest and the forests are not appreciable factors in harboring or disseminating it.

The length of time that a tree will live after it becomes infested depends upon the hardiness of the tree and the age at which it becomes infested. With peaches from two to six years (depending on age) will usually be fatal, while for apples from two to ten years is required to kill, or perhaps they may not entirely die at all from the scale.

There are certain natural enemies which have a tendency to reduce the numbers of the scale, or at least to prevent its becoming so abundant as it otherwise might. Several species of internal insects parasites infest it, while more than one of our native lady-beetles devour it. A fungous disease also does some good work, while only in recent years the U. S. Department of Agriculture introduced a Chinese species of lady-beetle for which great things were hoped but which has been unequal to the emergency.

For nearly ten years after this pest was discovered in the eastern states fruit-growers relied upon emulsions of kerosene or

solutions of soaps to subdue it, and the more skillful, careful and resourceful growers were enabled to keep their orchards profitable, even though badly infested. During 1901 and 1902 experiments were made which demonstrated that the lime-sulphur-salt wash, long in use on the Pacific coast, was useful here also and it quickly came into general use. Within another two years it was clearly demonstrated that the salt was not of material value in the mixture. The mixture as now most widely used in this state consists of 20 pounds lime and 17 pounds sulphur, boiled an hour, to 50 gallons of water, the wash being sprayed on the trees while still hot or warm. This remedy not only holds the scale in practical control, but also retards other insects to some extent, and is also claimed to be quite an effectual preventative of leaf-curl of peaches. Certainly it is efficacious in removing much moss, lichens and loose dead bark from trunk and branches and it seems to promote a healthy growth of new wood and bark. Indeed, so marked have been the benefits from this wash that many thoughtful, sensible fruit-growers declare that, all things considered, the appearance of the San José Scale in their orchards has worked to their ultimate advantage rather than otherwise. Certainly the appearance and spread of the pest has caused our fruit-growers to awaken to the importance of other insects also, as nothing else had done before,—and the science of Economic Entomology has gained a decided impetus from it.

* * *

Referring again to the present known conditions with regard to the San Jose Scale in this state,—it has been my frequent experience to be asked by really intelligent and apparently otherwise well-informed men, whether this pest is actually known to occur within the borders of North Carolina. In order that at least every person here present may be assured in the affirmative on this point I present herewith a map of the state on which each locality where the scale is known to exist, no matter how slightly, is marked with a black dot. The numbers refer to the number of different premises actually known to be infested in the county. Localities which seem to be generally infested

with the San José Scale (the pest presumably being present in all or most of the orchards) are marked with black circles or ellipses, etc. as the case may require to denote the infested territory. It must be remembered that this records the present conditions only so far as known to us, and our knowledge is probably far from complete.

Without going into a detailed consideration of each county a few general considerations may be of interest. The map shows the scale recorded in 65 of the 98 counties in the state. It shows145 different localities infested (and really there are more as a locality as here designated includes all who are served by the rural mail routes from that point) and the complete list numbers 423 separate premises. In 17 communities the scale is generally distributed. We find that it is in the counties of Cherokee, Haywood, Mitchell and Watauga bordering the Tennessee line, and in the east it is found in the counties of Brunswick, New Hanover, Carteret and Pasquotank. With regard to elevation, it occurs at sea-level in Brunswick and but little higher in Carteret, Beaufort and Pasquotank, yet it is also found at 3,000 ft. elevation in Haywood and at about 4,000 ft. in Watauga. The area of heaviest infestation seems to be the piedmont, but the fact that this is the most thickly settled region, has been more frequently visited and inspected, and that we have more correspondence among farmers in this section than others explains this condition to some extent. The records of one case each in the counties of Craven, Beaufort and Pasquotank are due to the activity of Prof R. I. Smith, Entomologist of the Experiment Station who discovered these cases while on a recent Farmers' Institute tour through this section,—and they go to show that the scale is far more widespread than our records yet indicate.

We know therefore that the San José Scale is already wide spread in the state. It is a *safe presumption* that it is in many localities in addition to those on record. It is a *reasonable presumtion* that it is in every county in the state, though we connot yet rightfully presume that it is present in every locality, and there is every reason to suppose that there are many individual orchards which are yet free from its attacks. But it is plainly evident that

no section of the state is immune, and no man can safely presume that his neighborhood is free from it. It is firmly established as a permanent pest to be taken into consideration from the outset be every person who enters the fruit growing business.

It is difficult to say which county is the worst infested. Based solely on the number of infested premises on record Catawba county leads with 62 cases, Guilford second with 32, and Gaston a close third with 31. Based on the number of localities where scale is known to exist Surry leads with 9 localities, Guilford second with 7, while Moore and Gaston tie for third place with 6 infested localities each. The following table briefly indicates the recorded conditions for each county which is known to have 5 or more localities in which there is San José Scale.

County	No. Localities Infested	No. Premises Infested	Average Premises per locality.
Catawba	5	62	12 2-5
Surry	9	27	3
Guilford	7	32	4 4-7
Moore	6	28	4
Gaston	6	31	5 1-6
Wake	5	21	4 1-5
Polk	5	16	3 1-5

In conclusion it should be repeated that all the statements as to the present conditions in this state are based solely on the *present available records.* New cases are still coming to light almost every week.

Raleigh, N. C.

6

JOURNAL

OF THE

Elisha Mitchell Scientific Society

NOVEMBER, 1908

VOL. XXIV. NO. 3

MONAZITE AND MONAZITE MINING IN THE CAROLINAS*

BY JOSEPH HYDE PRATT AND DOUGLAS B. STERRETT

Introduction

Monazite is one of the minerals which for a long time was considered rather rare in its occurence, but upon a commercial demand arising for it prospectors and engineers soon located large deposits of it in the Carolinas and Brazil, and the supply has always been able to meet the demand. During the past year further sources of supply of monazite have been discovered and developed in Idaho. North and South Carolina, however, are the only states that have thus far put any monazite on the market.

This mineral is essentially an anhydrous phosphate of the rare earth metals, cerium, lanthanum, and didymium (Ce, La, Di) PO_4. There is nearly always present a varying but small percentage of thoria (ThO_2) and silicic acid (SiO_2), which are very probably united in the form of a thorium silicate ($ThSiO_4$). Some monazites contain but a fraction of a per cent of thoria, while others have been recorded that showed the presence of 18 to 32 per cent;

*Paper read at the Chattanooga meeting of the American Institute of Mining Engineers, October 1908.

but the majority contain from 3 to 9 per cent of this oxide. It is the presence of the thorium oxide that gives the monazite its commercial value. The analysis occasionally shows also the presence of other constituents, as the yttrium and erbium oxides, zirconia, alumina, magnesia, lime, iron oxides, manganese oxide, and titanium ozide.

Monazite is light yellow, honey yellow, reddish, brownish, or greenish yellow in color, with a resinous to vitreous luster, and is translucent to subtransparent. It is brittle with a conchoidal to uneven fracture, and is from 5 to 5.5 in hardness. It crystallizes in the monoclinic system, and some crystals have been observed that were 2 inches in length. The more perfect crystals are, however, very small, ranging from an eighth to a sixteenth of an inch in length down to microscopic ones.

The mineral is usually readily recognized after a few samples have been examined. Its color, usually yellowish inclined to reddish, its hardness 5 to 5.5, being readily scratched by feldspar (hardness 6) or quartz (hardness 7). and its high specific gravity, 4.64 to 5.3, are the chief microscopic properties that will aid in distinguishing it. The principal chemical and blow-pipe reactions that can be readily employed to identify monazite are the following: It is incompletely soluble in hydrochloric acid, but is completely and readily acted upon by sulphuric acid. If oxalic acid is added to the very dilute filtered sulphuric acid solution, or to the solution obtained by fusing the mineral with soda, a precipitate is obtained which upon ignition becomes brick red, due to cerium oxide. Before the blowpipe the mineral turns gray, but is infusible. If heated with sulphuric acid, it colors the flame bluish green, due to phosphoric acid.

The presence of the thoria content of the monazite, which is the substance for which the mineral is mined, varies quite widely from .01 to over 7 per cent. The following analyses of thoria will illustrate the variation in the percentage of this oxide.

Percentage of thoria (ThO_2) in North Carolina monazite sand.

	1	2	3	4	5	6	7	8	9	10
ThO_2...	2.15	2.25	6.54	1.27	6.30	2.48	5.87	6.26	3.98	1.93

1. White Bank gold mine, Burke County.
2. Hall Creek, Burke County.
3. Linebacher place, Silver Creek, Burke County.
4. Long Branch, McDowell County.
5. Alexander Branch, McDowell County.
6. MacLewrath Branch, McDowell County.
7. Proctor farm, near Bellwood, Cleveland County.
8. Wade McCurd farm, Carpenters Knob, Cleveland County.
9. Davis mine, near Mooresboro, Cleveland County.
10. Henrietta, Rutherford County.

These results are for the concentrated sand, but in a number of cases they could have been concentrated to a higher degree of purity and thus contain a higher percentage of thoria.

GEOGRAPHY

Monazite is of wide spread occurrence in the United States, though commercial deposits have been found in but few regions. The area in which monazite deposits of commercial value have been found in the Carolinas lies in the south central part of western North Carolina and in the extreme northwestern part of South Carolina. This area covers about 3,500 square miles and includes part or all of Alexander, Iredell, Caldwell, Catawba, Burke, McDowell, Gaston, Lincoln, Cleveland, Rutherford, and Polk counties in North Carolina; and Cherokee, Laurens, Spartanburg, Greenville, Pickens, Anderson, Oconee counties in South Carolina. The larger towns within or near the monazite region in North Carolina are Statesville, Hickory, and Shelby; and in South Carolina, Gaffney, Spartanburg, and Greenville. This monazite region is crossed by the Southern, the Seaboard Air Line, and the Carolina & North Western railroads.

Several deposits of monazite have been located in northeastern Georgia, though their value has not yet been determined. One of these in Rabun County showed a good quantity of both gold and monazite in a preliminary test. In the adjoining Jackson County

of North Carolina, monazite was found in several pannings that were made in the Horse Cove region two miles east of Highlands. At a number of other places in the mountain region of North Carolina monazite occurs in pegmatized gneisses and schists. Several small deposits of fairly rich monazite bearing gravels are reported by Mr. Geo. L. English to occur in Clay County, North Carolina. The lack of large areas of bottom lands, however, limits the value of these deposits. It has also been found to a limited extent in Cub Creek near Wilkesboro, Wilkes county, North Carolina.

PHYSIOGRAPHY

Physiographically, North and South Carolina are divided into three parts. These are the coastal plain, extending from the Atlantic Ocean northwestward for a 100 to 150 miles; the Piedmont Plateau, extending from the limits of the coastal plain northwestward for 100 to 130 miles to the foot of the Blue Ridge; and the mountain region extending northwestward from the Piedmont Plateau to the State lines. The coastal plain and the Piedmont Plateau are prominent in both States, but only North Carolina contains a large portion of the mountain area.

The coastal plain is a broad, nearly flat stretch of country rising from sea level on the southeast to an elevation of a few hundred feet on the northwest, in which direction it is practically limited by the boundaries of the rock formations of which it is composed. The Piedmont Plateau is an elevated district rising from a few hundred feet above sea level on the southeast to 1200 or 1500 feet on the northwest. It forms a plateau much dissected by valleys from 50 to 200 or 300 feet deep, and its regularity is further disturbed by scattered mountain peaks and smaller hills rising above its general level. The features of the plateau are best observed from a prominent ridge or one of the smaller hills of the region. In the mountain region are included the Blue Ridge and its foothills, and the higher mountains to the northwest. The country in the mountain region is exceedingly rough, and the elevations range from 1500 to over 6500 feet.

The region in which valuable deposits of monazite have been found may be defined as a belt from 20 to 30 miles wide and over

150 miles long. This belt lies wholly within the Piedmont Plateau and borders closely on the Blue Ridge, to whose general course it is roughly parallel.

GEOLOGY

Formations

The rocks of the Carolinas monazite region are principally gneisses and schists. These include the Carolina and Roan gneisses; granite gneiss and porphyritic granite gneiss. Among other rocks are massive granite, pegmatite, peridotite and allied rocks, quartz diorite, and diabase.

The Carolina gneiss is of Archaean age and is the oldest and most important rock of the region. It is composed of several types of gneisses and schists which exhibit various degrees of metamorphism. The most common types are mica, garnet, cyanite, and graphite gneisses and schists or combinations of two or more of these types. The mica of the micaceous types may be either biotite or muscovite or both. More or less mica is generally present in all of the types of the Carolina gneiss, while the garnet and cyanite types with or without the graphite type also occur together. The different types of the Carolina gneiss vary in color from light gray to dark gray and are sometimes bluish gray or bluish black where graphite is abundant in them. Some types of the Carolina gneiss are fine grained so that the component minerals are distinguished with difficulty, while others are more coarsely crystallized. Some of the common constituent minerals of the Carolina gneiss are biotite, muscovite, quartz, garnet, cyanite, feldspar, and graphite. The presence of much pegmatitic material is a characteristic feature of much of the Carolina gneiss.

The Roan gneiss is the next oldest formation of the monazite region and is also of Archaean age. It consists of hornblende gneiss and schist, with occasionally the less metamorphosed phase diorite. The hornblende gneisses and schists are composed chiefly of small interwoven and matted hornblende crystals and grade into diorite which contains a noticeable amount of feldspar and has a granitoid texture. The hornblende rocks vary from black to dark green in color. Bands of mica gneiss and schist, possibly of the Carolina gneiss, are included in both large and small masses of the Roan gneiss.

The age of many of the granites and granite gneisses has not been determined though a part are probably Archaean. The granites and their different phases are next to the Carolina gneiss in importance, and are particularly prominent in areas where rich deposits of monazite exist. The types found in the monazite region are biotite granite, muscovite, and hornblende granite, while in some places considerable secondary garnet has developed in the gneissoid granites. The texture of the granites are gneissic or schistose, porphyritic, and massive. Where the granite is both porphyritic and schistose the feldspar phenocrysts often have an augen form, caused by crushing and shearing. Many of the granite masses have much quartz in veins and veinlets throughout their mass. Some of this quartz is massive crystalline and other occurs with more or less well-defined crystal form, or drusy surfaces. The occurrence of quartz veins is not always confined to the granite masses, but in many places extends some distance from the contact of the granite into adjacent formations. The composition of the granite masses near the contact with other formations has in many cases been altered by the partial or complete absorption of inclusions of those formations. This phenomena is particularly evident where a mica granite, by intrusion into a mass of Roan gneiss, has become a hornblende granite near its borders through the absorption of hornblende.

Pegmatite is a common rock throughout the monazite region and is especially prominent in those areas rich in monazite. Two principal methods of occurrence are here recognized. In one the pegmatite occurs in distinct masses or bodies composed of quartz and feldspar, with or without mica and other accessory constituents. The texture of these masses is, in some cases, extremely coarse with the minerals composing the pegmatite separated out in crystals or masses many inches across. The other type is pegmatized gneiss, representing the addition of the pegmatite minerals to the gneiss, with perhaps some recrystallization of portions of the inclosing rocks. The nature of this pegmatized rock varies considerably. In some places secondary quartz is the principal mineral added, while feldspar is present in smaller quantities. In others feldspar is more prominent. Mica may or may not be

present in the pegmatitic material but has generally been plentifully developed in the mass of the gneiss by metamorphism. The feldspar of pegmatized gneisses often assumes a porphyritic form producing augen gneisses. The gneisses and schists are often banded with or cut at all angles by streaks of pegmatitic or granitic material. The recrystallization of the gneisses and schists, with the development of pegmatitic material or the injection of such material through the rocks, may be called pegmatization. In many places the process has proceeded so far that it is very difficult to distinguish pegmatized gneiss from granite gneiss, especially from porphyritic and flow-banded granite gneiss. This difficulty is partly due to the fact that granite and pegmatite are composed of the same minerals and have no sharp division line between the size of their grains.

The peridotites and allied basic rocks are dark-green to greenish black in color and contain one or more of the ferromagnesian minerals, olivine, pyroxene, and hornblende as chief constituents. So far as known these rocks are of Archaean age and are probably genetically connected with the Roan gneiss. Though a relatively unimportant rock of the monazite region, these basic rocks generally outcrop prominently wherever they occur, and many of the outcrops are marked by large rounded "nigger-head" bowlders. The peridotites and allied rocks are often altered to talcose or chloritic soapstone or serpentine. In some cases this alteration is only superficial, but in others whole masses have been so metamorphosed. These rocks generally occur in lens-shaped bodies parallel. or nearly so, to the schistosity of the inclosing rocks.

Quartz diorite of undetermined age is one of the less important intrusive rocks of the monazite region. It is a hard, fine grained rock, composed of granular quartz and feldspar with varying quantities of hornblende. Locally, garnet is distributed promiscuously through it. Quartz diorite occurs in small dikes, from a few inches to several feet thick. cutting the formations at various angles. Their size is offset by their abundance in some sections and resistance to erosion, owing to which they leave much debris over their outcrops in the form of hard rounded bowlders.

Diabase, probably of Triassic age, is the latest intrusive rock known in the monazite region. It is a dense, hard rock of dark

green to black color, composed chiefly of olivine and a lime feldspar and is rather abundant in some seetions and occurs in dikes from a few to over a 100 feet wide. The outcrop is generally marked by abundant characteristic spheroidal "nigger-head" bowlders. The diabase dikes cut the rocks at various angles, though in many cases they have a north to northwest strike.

STRUCTURE

The rocks of this region have undergone extreme regional metamorphism, with accompanying folding and faulting. The mashing and recrystallization of the rocks of the Carolina gneiss formation have been so extensive, in some cases, that much of the original sedimentary structure and igneous texture have been destroyed. The folding of the older formations has resulted, in some places, in complex structure of both large and small dimensions. Some of the folds extend over miles of region, while others are confined to a few feet or inches. The minor deformations and crumplings—miniature Appalachian folds—seen in some rock exposures portray the form of the larger folds. The Carolina gneiss has been intruded by rocks of later age and cut by them into irregular-shaped masses, many of which fork out into long tongues or occur as narrow streaks in the intrusives or vice versa. There have been successive intrusions of igneous rocks of later age into the earlier formations. Thus the Carolina gneiss is cut by the Roan gneiss, and both are cut by grañites of later age.

The structure of the pegmatite in this region is quite variable. In some places the pegmatite occurs in sheets or lenses interbedded and folded with the inclosing gneisses and schists. In other places it occurs in dikes, veins, or lenses either conformable with the inclosing rocks through part of its extent and cutting across them in other parts, or in irregular masses having no definite orientation in the surrounding formations. In pegmatized rock masses pegmatization has generally affected certain beds, which grade into regular pegmatite in either the direction of their greatest or that of their least extension. In such rocks it is often impossible to determine the line of demarcation between the two. There is also a gradation between the pegmatized beds and ordinary gneiss.

ROCKS AND SOILS

The rocks of the southern Appalachain region have undergone extensive weathering and in many places in the Piedmont Plateau, especially, are concealed by a thick mantle of residual soil. In many sections good outcrops are scarce and are found mostly on steep hillsides, along water courses and in road cuts. The residual soils often furnish evidence of the nature of underlying rocks and can be used as a guide to their determination. It is first necessary to learn the different stages of soil formation by the examination of many outcrops and their graduations into residual soil.

The Carolina gneiss, on partial disintegration and decomposition, commonly forms a gravelly soil with a red clayey matrix. This is especially characteristic of the garnetiferous and graphite-cyanite types, which are abundant in parts of the monazite region. The pebbles are composed of small fragments of the original rock, such as tufts of cyanite impregnated with hematite or limonite, iron stained garnets, or pieces of hematite. On more complete decomposition a fine reddish clayey soil results, with no decided characteristics. Other types of the Carolina gneiss, in which mica is an important constituent, leaves a micaceous soil, much of which assumes a purplish color. Granite and its various phases, on partial disintegration and decomposition, yields light sandy soils. On more complete decomposition the granites yield soils of a light to dark reddish color, depending on the quantity of ferromagnesian minerals. as biotite or hornblende, in the original rock. The quartz grains of the granite remain as sand mixed through a clayey matrix. This quartz sand is almost everywhere to be seen at the immediate surface, from which the clays have been washed by rains. Where Carolina gneiss and granite are intimately associated, or where pegmatization has been extensive in a body of Carolina gneiss, there results a sandy soil, characteristic of granite, through which are scattered pebbles of hematite and ferruginous cyanite, characteristic of the Carolina gneiss. The relative importance of pebbles in such soils decreases as the quantity of pegmatite or of granite in the rock formations increases. These features of the soils are especially marked on the broad, flat ridges charac-

terizing much of the Piedmont Plateau region. The Roan gneiss leaves a greenish sandy soil on disintegration, and an ocher-yellow to dark reddish brown or chocolate-colored clayey soil on decomposition. Black stains of manganese are associated with many of the soils derived from hornblendic rocks.

A clew to the nature of the rock formations in a given region is often furnished by the character of the gravels in the bottom lands and streams draining that region. Thus in this area a very light colored gravel with much quartz debris indicates a granite or its contact or a very highly pegmatized country rock. Garnets and hematite iron ore, with which blocks of mica or cyanite gneiss are associated, indicate Carolina gneiss. Quantities of black sands in the stream gravels, containing magnetite, ilmenite, hornblende, etc., are characteristic of the Roan gneiss.

OCCURRENCE

Monazite has been found in several varieties of rocks, in the soils derived from monazite bearing formations, and in gravel beds formed through the erosion of these formations. Only gravel deposits have been profitably worked for monazite on an extensive scale, though in some places the surface soils adjoining rich deposits of monazite, or the saprolite or rotted rock underlying them, are found to be sufficiently rich in monazite to be sluiced down and washed.

The percentage of monazite in both the original rock matrix and in the gravel deposits is small, and probably does not often run over 1 per cent. Figures are not available for the percentage of monazite in gravel deposits. From the saprolite underlying the F. K. McCurd mine, three-fourths of a mile northeast of Carpenter Knob, N. C., Mr. George L. English obtained about one-third of a pound of monazite per ton, or about 0.016 per cent. At the British Monazite mine, 3 miles northeast of Shelby, N. C., the quantity of monazite in the hard rock formations was found by Mr. Hugh Stewart, engineer in charge, to run from between 0.03 per cent and less up to over 1.10 per cent.

MONAZITE-BEARING ROCK

Monazite has been observed in the Carolinas in several types of rock, among which are gneiss, pegmatized gneiss and schist, pegmatite, and different varieties of granite. The occurrence of monazite in ordinary pegmatite masses is in large masses of crystals. These have been found varying from an ounce or two to several pounds in weight in the mica mines of Mitchell and Madison counties, N. C.

Most of the pegmatized gneiss bodies which are rich in monazite represent phases of the Carolina gneiss in which the original nature of the rock has been largely obliterated as a result of the addition of new minerals and the recrystallization of the original ones into pegmatitic material. The texture developed during this pegmatization is in many cases porphyritic, in which the feldspar phenocrysts assume somewhat of an augen form. The feldspar phenocrysts range in size from some smaller than a grain of wheat to others the size of a walnut. The porphyritic gneiss may grade into less or more highly pegmatized gneiss, and from the latter into regular pegmatite. This gradation may be between two separate beds or from one part to another of the same bed. In those beds or portions of beds where there has been little pegmatization monazite occurs sparingly. The same is true where pegmatization has been complete and but little of the original gneiss remains. It is, then, the beds of gneissic rock which are rich in secondary quartz and contain numerous small masses of feldspar throughout that carry the most monazite. In such rocks there is generally much biotite, with graphite and perhaps some muscovite and other accessory minerals, as well as abundant quartz and feldspar. The quartz occurs in layers or scattered grains throughout the rock, inclosing and replacing the other constituents. The feldspar crystals chiefly replace, though they partly displace the other minerals of the rock, Monazite in a rock matrix almost invariably possesses crystal form, often with brilliant faces.

A typical example of rich monazite-bearing rock could be described as follows: The chief constituents of the rock are quartz, feldspar (mostly the potash variety), biotite, graphite, muscovite, monazite, and a little zircon. It has a banded stuc-

ture caused by the more or less separate occurrence of certain minerals arranged in parallel streaks, with a roughly parallel orientation of the crystals or grains of each mineral. The principal features of the banding consist of larger quartz streaks with several smaller ones and individual grains in a regular biotite schist. The other minerals occupy various positions and show diverse relations to the minerals of these bands and to each other. The feldspar is porphyritic and occurs chiefly in individual crystals, some of which are of considerable size. A number of the feldspar phenocrysts are small bodies of pegmatite in themselves. The feldspar phenocrysts replace the other minerals. Graphite occurs in large amounts with biotite, though it is associated with nearly every other mineral of the rock. Where present, muscovite is chiefly associated with the feldspar. Monazite seems to be indiscriminately scattered through the rock, included in or associated with all the foregoing minerals. Though generally free from inclusions, it is not invariably so, and in one case a plate of graphite was observed within a monazite crystal. All the minerals observed in the rock, with the exception of zircon, have been noted as inclusions in the feldspar phenocrysts.

In microscopic sections cut from specimens from one of the ore streaks, the minerals described above were observed, together with some iron staining. The feldspar is principally orthoclase and microcline, partially kaolinized. The quartz is plainly secondary, and occurs in bands or streaks or grains parallel with the schistosity of the rock. In some places the quartz has been deposited in the fracture or between the grains of other minerals; in others it replaces or includes fragments of such minerals as biotite and graphite.

Gas cavities and inclusions of very fine acicular needles, probably rutile, are abundant in the quartz. Biotite occurs in interwoven laths and crystals roughly parallel to the banding of the rock. The pleochroism of the biotite is light yellow-brown to greenish brown or dark purplish red. Graphite occurs as plates and laths, in general lying parallel to the banding of the rock. Some of it is interbanded and even interleaved with biotite; elsewhere the plates are turned across the foliation. In one section a lath of graphite was observed inclosed in quartz which filled a

fracture across the foliation of a biotite crystal. Monazite occurs in contact with the various minerals of the sectoin, though it is more commonly surrounded by or included in grains of biotite and quartz. The position of the monazite in the biotite indicates replacement, and the biotite foliae are not displaced around the crystals. In the microscopic sections sufficient feldspar was not observed to determine its relation to the other minerals.

The rock has been so thoroughly recrystallized that it is difficult to give the relative order of formation of the minerals. Biotite, if not still in its original condition, was probably the first mineral to form during recrystallization. Part of the graphite was probably contemporaneous with the biotite. Some, however, was introduced later and formed at the same time with the quartz. The small amount of muscovite in the rock was probably next to form, followed closely by quartz. From the small amount of feldspar in the microscopic sections, it was not possible to state its relative period of formation. From the hand specimen, however, it is evident that the feldspar was introduced later than the quartz, or possibly contemporaneously with part of it.

ORIGIN

The occurrence of monazite in granitic and pegmatitic rocks indicates that its origin is associated with magmatic agencies. It is probable that the constituents of monazite are associated with granitic magmas and that only part of the mineral crystallizes out when such magmas solidify. During the formation of pegmatite magmas and solutions from the residues of the solidification of granite part of the constituents of monazite are retained. When these pegmatite magmas and solutions are intruded into or deposited in the gneisses and schists in masses such as are mined for mica, monazite forms in large masses or crystals. During the pegmatization of rock formations by these magmas and solutions the monazite is carried into the gneisses and schists where it is now found. This pegmatization with which monazite is associated was probably produced by the passage of active magmatic solutions through the rock, both aiding in recrystallization of the original constituents, and depositing the materials held in solution when conditions of temperature or agents of precipitation were favorable.

It is possible that in some cases the monazite in pegmatized gneiss is formed by the gathering together of the proper elements disseminated through the original rock during recrystallization. It is probable that pegmatization in which much quartz with but little feldspar has formed represents a phase of recrystallization in which the quartz may either in part or wholly have come from the original rock itself or may have been added by solutions passing through the formations. In either case the materials do not represent the work of active magmatic solutions or magmas such as might give rise to regular pegmatite bodies. In those recrystallized or pegmatized rocks where the feldspathic component of pegmatite is not plentiful, monazite occurs but sparingly. On the other hand, monazite is found more abundantly in pegmatized rock formations in which feldspar plays a prominent part. The common proximity of this form of pegmatization to granite masses, or its gradation into pegmatite bodies, gives evidence of its formation through magmatic agencies.

The monazite of rock formations has, then, probably been derived from aqueo-igneous solutions such as give rise to certain forms of pegmatite and have in these cases affected large masses of rock.

PLACERS

The commercial deposits of monazite occur in the gravel beds of creeks and streams and in the bottom lands adjacent to them. The thickness of the gravels ranges from a foot or two, including over-burden, to 6 or 8 feet. The distribution of the monazite in them is, as with all heavy minerals, richer near the bed rock and poorer above, grading into the over-burden. In some deposits the whole thickness of the gravel, with the finer alluvium at the surface, is rich enough to be washed directly or sluiced down and washed. The extent and value of these deposits vary with the topography of the country and the nature of the gravels. In some places the bottom land, containing rich monazite-bearing gravels, are over 100 yards wide and extend a half a mile or more along the streams. In other places the bottom lands are small and there is but little more than the stream gravels present. The best deposits are more commonly associated with light colored gravels and sands, con-

taining considerable quartz debris and fragments of other light colored rocks, such as pegmatite, granite, mica, and cyanite gneiss. On the other hand, the absence of much quartz and pegmatitic or granitic debris from the gravel is generally characteristic of low grade deposits of monazite. The presence of black sands—magnetite, ilmenite, hornblends, etc.—in the gravels does not necessarily indicate a low grade deposit, unless quartz and pegmatitic minerals are also lacking. Monazite deposits in regions where hornblende rocks are abundant generally contain a large percentage of black sands, and it is then often difficult to concentrate the monazite to a marketable grade. As an offset to this, however, especially in regions where granite is associated with the hornblendic rocks, gold is often found in the concentrates in quantity more than sufficient to pay the cost of separation, and in the same localities the concentrates generally carry also a quantity of zircon. This zircon is in the form of small, clear crystals with brilliant lustre, which range in size up to 1 millimeter square and about 2 millimeters long.

RESIDUAL DEPOSITS

It has been found profitable to sluice down and concentrate the surface soils on the lands adjoining some of the richer monazite bearing deposits. The residual soils that have suffered but little displacement on the surface can be thus profitably washed to a depth of 3 or 4 inches, and where the drift soil has collected on the gentle slopes below a steeper hillside several feet can be sluiced down in some cases. The partial concentration of monazite in the top layer of soil is caused by the washing away of the clay and other light decomposition products of the rock. The supply of monazite in the stream gravels in favorable areas is often replenished by the wash from the hillside soils during rains; especially where the hills have any considerable slope and the land is cultivated. Under such conditions the stream gravels are often worked two or more times in a year.

The saprolite or rotted rock underlying the richer deposits of monazite is at some places sluiced down to depths of a few inches to a foot or so, along with the overlying gravels. At other places small amounts are removed and washed separately for the mona-

zite they contain. The formations that have been found especially favorable for such work are highly pegmatized gneiss or schist. Such deposits have generally soon been lost or grown poor, probably on account of the fact that the miners have cut through the richer bed or failed to follow it in the direction of its extension. The occurrence of monazite in saprolite is merely an altered phase of the occurrence in hard rock formations.

COMMERCIAL DEPOSITS

All the monazite mined in the Carolinas is obtained from gravel deposits which lie in and along the stream and creek beds where the monazite is collected after being liberated from the rocks by their alteration and erosion. While no accurate record has been kept of the percentage of monazite in these gravel deposits, yet it is undoubtedly true that the percentage per cubic yard, reckoning from surface to bed rock, is not over 1 percent. This, however, is sufficient to make profitable mining. In many localities it has been the custom to sluice not only the gravels but all the overburden, inasmuch as even the top soil carries a small amount of monazite.

There are no large hydraulic plants in operation, but nearly all the monazite is obtained in sluice boxes fed by hand. These boxes are fitted at their upper end with a sieve or shaking hopper with a mesh of about No. 12. The boxes vary in length from 8 to 20 feet, and in some instances are fitted with riffles holding mercury for catching the gold. An interesting fact noted in connection with the deposition of monazite in the stream beds is that when the gravels have been washed for monazite and then left for a few months or a year (especially if there has been considerable rainy weather), there is another supply of monazite deposited, which in many cases can be profitably worked. This monazite has resulted from the washing in of the mineral from the surface adjoining the streams where it had been during the decomposition and erosion of the original rock matrix. This second deposition of monazite is facilitated by plowing the adjoining fields. In a few places Wilfley tables have been introduced for treating the concentrates from the sluice boxes. Where these tables are used the soil and

gravels are washed into shaking hoppers and then through sluice boxes, the over size thrown out and the sands fed to Wilfley tables. At one mine it is necessary to raise the gravels by a mechanical elevator in order to bring them to a sufficient height to feed them to the table. They are fed into a revolving screen and from that to the table. The heads from this first washing do not contain a very large per cent of the monazite, and the middlings are, therefore, re-fed to the table with other feed ore. In some cases the feed ore is all run over the machine and a rough concentrate first obtained and then this re-fed. The product from these machines contain from 50 to 80 and occasionally 90 per cent of monazite. Where there is a large amount of the heavy black sands occurring in the gravel with the monazite, it is almost impossible to get the percentage much over 50 per cent monazite. Where, however, these occur more sparingly, it is possible by this method to obtain a monazite concentrate containing 80 per cent monazite.

All the concentrates from the sluice boxes and Wilfley tables have to be dried before they can be treated on the magnetic separators. There are two different methods used in the monazite district for this purpose. In one the sand is spread over an oiled or rubber cloth in a thin layer and exposed to the heat of the sun. It dries very quickly, due perhaps partly to the heat absorbed by the dark iron sand. It requires, however, a considerable surface to accommodate any large amount of sand. The other method of drying is by heating over furnaces. A small ditch from 4 to 8 feet long and 1½ to 2 feet wide and about one foot deep is dug, at one end of which there is built a rock or brick chimney. The ditch is usually built up of stones with an opening at the opposite end of the chimney for firing. Over the ditch there is a sheet iron cover or drying plate. The monazite is spread on this and exposed to the action of the hot fire underneath. These dry sands are often further concentrated by means of the ordinary horseshoe magnet, which picks out all the magnetite. The miners are paid for their sand on the basis of 100 per cent product and the nearer they can bring their sand to this, the better prices they receive for

it. The sand brought into the magnetic concentration plants is worth from 4 to 8 cents per pound while after a magnetic separation, its value is increased to 12 to 20 cents per pound.

This material represents what is known as crude monazite sand and contains, besides the monazite, magnetite, ilmenite, garnet, zircon, rutile, corundum, cyanite, hornblende, and occasionally chromite. In order to separate the monazite from its associated minerals, it is necessary to run this crude sand through some electrical apparatus. There are two types of machines that are in operation: (1) the Wetherill electro-magnetic machine and modifications of this; and (2) machines in which the minerals are deflected by electro-magnets while falling. Of these, the first type is the one most generally employed. By means of these various machines a product can be obtained varying from 90 to 98 per cent of monazite and represents the sand that is shipped to the manufacturers of the incandescent mantles.

MAGNETIC SEPARATION

The first application of magnetic separation was in the concentration of certain iron ores, principally magnetite, in order to produce a product richer in iron and also to eliminate certain minerals that contained elements injurious to the metallic iron. The next application was to other iron ores such as limonite, hematite, and siderite after they had been given a preliminary roasting to convert them into the magnetic oxide. The next step was in the separation of magnetic iron particles from certain copper, gold and zinc ores either before or after roasting. For many years this was the only application made of magnetic separation. It was found, however, upon experimenting with an electro-magnet with a higher intensity that other minerals were subject to magnetic attraction and that it was possible to separate minerals into more or less pure products by varying the intensity of the magnetic field. Thus, it has been possible to adapt this method of separation to ores containing iron or manganese, which are only weakly magnetic. As is well known, steel bars may be magnetized and they will retain more or less of this magnetism indefinitely, while bars of softer wrought or cast iron may be magnetized by means of electric currents in surrounding coils of insulated copper wire.

These iron bars do not become permanent magnets but form electro-magnets as long as the current flows around them. They can be given a greater and more constant strength than can be given to the permanent steel magnets and for this reason, in nearly all of the magnetic processes, electro-magnets are used instead of the field magnets.

The magnetism of these electromagnets can be varied and different intensities obtained ranging from indefinitely weak to a certain maximum strength. It is also possible to control the intensity of any magnetic field so that minerals that are strongly attracted may be separated from minerals that require a magnetic field of much higher intensity. This intensity of the magnetic field depends:

1. On the size of the magnet.
2. On the shape of the magnet.
3. On the distance between the magnet and the body to be attracted.
4. On the number of amperes turns in the magnet coil, that is, the product of the amperes or current flowing in the coil times the number of turns around the core.

There are many substances that are attracted by electro-magnets that are not influenced apparently at all by the strongest steel magnet and for this reason, formerly many substances which were considered non-magnetic, have been proved to be magnetic when subjected to the intense magnetic field obtained in an electromagnetic separator. All substances are of course either attracted or repelled by magnets and the former are called para-magnetic and the latter dia-magnetic. The latter class is the most numerous, but since the introduction of electromagnets, the former class, which up to this time had been considered extremely small, has been largely increased. The paramagnetic substances are the metals iron, nickel, cobalt, manganese, chromium, cerium, palladium, platinum, osmium and many of their salts and compounds. The degree of attraction of these varies very widely and, as an illustration between a strong and weak magnetic substance, it has been estimated that if the attraction of steel be taken at 100,000, then magnetite would be 65,000, siderite 120, hematite, 93 to 43, lim-

onite 72 to 43. By using the electromagnetic separators, which can be regulated so as to give a very strong field and at the same time a field which is capable of fine adjustment, it is now possible not only to separate the paramagnetic from the diamagnetic substances, but also to separate the paramagnetic from each other.

There are a large number of magnetic separators that have been invented, many of which are now on the market. Perhaps the simplest of all these magnetic separators is one devised by Edison. In this separator the particles of mineral are permitted to fall in a thin sheet in front of the poles of a strong bar electromagnet, which causes a deflection of the magnetic particles from a direct downward path, while the nonmagnetic particles would not be influenced by this attraction and would fall vertically. It is possible to make two and sometimes three products in this way.

There are three general classes of these magnetic separators as follows: (1) in which the magnetic particles are held to revolving cylindrical rolls or drums within which are magnets; (2) those in which the magnetic particles are carried by conveying belts or pans passing over the magnets; (3) those in which the ore falls in front of a magnet. There are a number of points of difference in the machines such as permanent or electromagnets; treating the ore wet or dry; magnets acting continuously or intermittently; and the use of direct or alternating current. It will be found that different machines are suited for different purposes according to the character of the material to be treated. As I have stated before, most of the machines were originally designed simply to treat iron ores, or to separate iron minerals from other ores and there are but few of them that are adapted for the separation of monazite, zinc minerals, etc.

The first class is represented by the Ball-Norton separator which consists of two revolving drums within each of which is a series of stationary electro-magnets so wound that opposite poles are adjacent to one another. The capacity of a machine with 2 drums 2' dia. and 2' face raises 15-20 tons per hour, 16-20 mesh. The ore is fed upon the top of the first drum and the magnetic particles are held by the drum, while the non-magnetic fall into the hopper below. As the drum revolves, the magnetic particles get beyond

the magnetic field and are thrown by centrifugal force on to the second drum. This drum, which does not have quite so strong a current as the first, does not attract as many of the magnetic particles so that some of these drop off into a second hopper, forming a middling product, while the stronger magnetic particles are held by the drum and carried a certain distance, when they get beyond the magnetic field and are dropped into a third hopper. On account of the alternate polarity of the adjacent magnets, the particles roll over and thus facilitate the elimination of any gangue particles that may be mixed with the magnetic.

Another simple drum separator is the Heberli. In this machine there is but one drum and the electro-magnets extend over about one-fourth of the area of the drum. The ore is fed to the drum just above the centre radius and about the middle of the magnets. The drum revolves in the opposite direction to which the ore is fed and the magnetic particles are attracted by the drum and carried up and over the magnets ,while the non-magnetic particles drop into the hopper below. As the magnetic particles leave the magnetic field, they are dropped on the opposite side of the drum into another hopper.

2. It is the magnetic separators of the second class that have been used principally in the separation of monazite in the Carolinas. Of these machines, the Wetherill stands out most prominently and was probably the first to commercially treat weakly magnetic materials. The principal idea of these machines is to secure a very strongly magnetic field by concentrating the lines of force as far as possible, this being accomplished by placing the two poles of the magnet facing one another with a minimum air gap between them and by bevelling down the pole pieces to their end.

The type of the Wetherill magnetic separator that is more generally used is known as the Rowand type, which has a magnetic pole with sharp edge between the travelling feed belt and a blunt pole directly under it. Both of these poles are capable of being magnetised by an electric current which will produce a condition varying from weak to intensely strong magnetism. The concentration of magnetism at the sharp edge causes all the grains to jump to the upper pole. A cross-belt directly beneath this pole, which is running at right angles to the feed belt and is running

rapidly, readily takes off these grains and deposits them in a bin while the non-magnetic grains go on with the belt. There can be readily arranged above the travelling feed belt a series of such poles, each stronger than the one before, so that the first will take off the strongest magnetic particles. The travelling feed belt varies in width from 12 to 18 inches. The material fed to the machine is classified and allowed to pour over a revolving drum, which concentrates it evenly over the feed belt. The pole pieces are made of soft iron and weigh up to 90 pounds each. They are adjustable so that the length of ore gap between them may be varied. The strength of the current in amperes can be varied and also the distance of the feed belt beneath the poles.

The monazite sand, which is fed to the travelling feed belt, passes along under four powerful electo-magnets. The first removes all the magnetic iron and generally all of the titanic iron or ilemnite and any chromite that might be present. The second magnet removes all the fine grains of garnet, the coarser ones, if present, usually being removed by the first magnet. The third magnet is so adjusted as to remove only the coarser particles of monazite, while the fourth removes all the finer pieces of monazite. The remaining portion of the sand, consisting largely of zircon, quartz, and a little rutile, corundum, cyanite, etc., is dropped off at the end of the large belt into a waste pile.

In another type of machine used in the monazite district there are a series of magnets over which are travelling belts which pick out different minerals, according to the intensity of the magnetic field. In this machine the magnetic particles are carried over and under the magnet and dropped into a hopper as they leave the magnetic field, while the tailings are dropped into another hopper and fed to another travelling belt and over a second magnet of stronger intensity, which picks out the garnet. This is dropped into a special bin and the balance into another hopper and fed to a third magnet, whick picks out the monazite. It is possible by these separators to obtain a monazite sand of from 90 to 99 per cent monazite, according to the care that is taken in separating it.

The other products, as the iron minerals magnetite and ilmenite, and garnet, can also be obtained in a very pure state. From a long series of experiments that have been carried on, it has been

determined that in machines of this type the magnetite can be removed when the amperage is .2; ilmenite with 1.1; chromite with 1.6; garnet with 1.75; hypersthene and olivine with 2.2; monazite with 3.5 amperes. Zircon is left behind with the gold as non-magnetic. Any platinum that might be present would begin to be lifted by the weakest current, but most of it would not be lifted until the current was 1.5 amperes.

It is possible to separate almost completely pyrite from hornblende by picking out the hornblende with the electro-magnet, the pyrite remaining in the tailings. Such minerals as pyroxene, epidote, titanite, tourmaline, and serpentine are readily picked out by the Wetherill magnetic separator with a current of 2 to 2.5 amperes. Brookite and cassiterite can occasionally be picked out with an amperage of 3.5.

USES OF MONAZITE

The commercial value of monazite depends upon the incandescent properties of the rare earth oxides which it contains, such as cerium, lanthanum, didymium and thorium oxides, which are used in the manufacture of the Welsbach and other incandescent gas light mantles. It is the thoria that is used in largest amount and which gives the actual value to the monazite. In the reduction of the monazite sand, there are a number of the rare earth salts that are obtained in considerable quantity, which has made it possible to carry on an extensive series of experiments with these rare earth oxides. It requires from 4 to 6 months to recover from the monazite sand its percentage of thoria and render it sufficiently pure to be used in the mantles.

The Welsbach light consists of a cylindrical hood or mantle composed of a fibrous network of the rare earths, the top of which is drawn together and held by a loop of asbestos or platinum wire. When in use, this mantle is suspended over the flame of a burner, constructed on the principle of the Bunsen burner, in which the heating instead of the illuminating power of the hydrocarbon of the gas is used by burning it with an excess of air. In this manner the mantle becomes incandescent and glows with a brilliant and uniform light.

A short description of the method of manufacture of these mantles may be of interest. The first part of the process is the selection of the thread fibre from which the mantle fabric is knitted. The fibre mostly used is cotton, either the upland, river bottom, Peeler, Allen seed, Sea Island or Egyptian variety, the market prices varying from about 10c for the upland to 30c per pound for the Egyptian. The cheaper cottons are used in the lower grade mantles, the highest grade mantle requiring the best quality of cotton. The thread is purified, so as to remove every possible trace of mineral matter. If the thread used shows a mineral impurity above .015 per cent, it will introduce factors that will affect the physical and lighting life of the mantle. Cylindrical networks of varying diameters are knitted out of the thread and then washed in ammonia and distilled water and wrung out in mechanical clothes wringers. After it is dry it is cut into pieces sufficiently long to make two good mantles.

These knitted fabrics are then placed in a suitable vessel and covered with the "lighting fluid." They remain in this until thorougly saturated. The excess of fluid is drawn off amd the fabric put through an equalizing machine piece by piece. The "lighting fluid" is composed of a solution of approximately 99 per cent thorium nitrate and 1 per cent cerium nitrate in distilled water, in the ratio of 3 parts of water to 1 part of mixed nitrates. The fabric is dried and then cut to the proper length required for a hood. They are then shaped over a wooden form and the upper end drawn together by means of an asbestos cord (occasionally of platinum). After the mantle has been modelled the cotton fibre is eliminated by heating them over a hot Bunsen burner flame, leaving the mantle composed of the ash of thorium and cerium. The peculiarity of these oxides is that they have sufficient cohesion to hold together during the balance of the process of manufacture, after every bit of the supporting cotton thread has been burned away. They are then subjected to a series of tempering and testing heats during which the mantle is carefully shaped to its permanent form. In order to protect the ash of the mantle during its inspection, packing, transportation, and installation, it is dipped in collodion. Just before using a mantle this collodion cover-

ing has to be burned off. It is estimated that the American market consumes 40,000,000 of these mantles per year.

Another element obtained from the monazite is didymium, whose oxide is dark brown. Use is made of this for branding the mantles with an indelible brand. A nitrate solution is made and an ordinary rubber stamp used for branding.

Of the associated minerals, zircon has a commercial value of 20 to 25 cents per pound for its zirconia content, which is used in the manufacture of the glower of the Nernst lamp. The fundamental principle of this Nernst lamp is that certain of the rare earths or refractory oxides will conduct an electric current and glow after they have been heated to redness. This discovery, which was made by Dr. Nernst in 1897, has resulted in the development and perfecting of the glower which is now embodied in the Nernst lamp. This glower is composed of a mixture of the rare earth oxides and is made in the form of a small rod or pencil of chalk-like material, having wire terminals at either end. When cold, the glower is an insulator, but by means of the wire the glower becames heated to redness when a current is passed through these wires, and its resistance gradually decreases until it has reached a red heat, when with 220 volts across the terminals it starts to conduct the current and give light.

In bringing a glower up to its starting point corresponding to a temperature of 1,200° F., use is made of a small electrical heater composed of two or more small tubes of porcelain, about 1½ inches long and ¼ inch in diameter, which are overwound with fine platinum wire, this in turn being held in place and protected from the intense heat later generated by the glower by an outer coating of porcelain paste. After the glower becomes heated, there is, of course, no further use for the heater, and it is cut out by a small electro-magnet cut-out, which consists of a magnetic coil connected in series with the glower, an armature, and the necessary contacts in the heater circuit. Thus, when the glower has become heated sufficiently, the current begins to pass through it, and when this becomes sufficiently strong the armature is attracted and the contacts are separated, thus disconnecting the heater from the line. The surface of the glower before being used presents a

smooth, white, porcelain or chalky appearance, but after having been in use about 500 hours, it is rough or crystalline in appearance.

The yttria contents used in the manufacture of the Nernst glower are obtained principally from the mineral gadolinite, which has not thus far been found in North Carolina. There are, however, a number of minerals containing yttria, such as samarskite, euxenite and fergusonite, which have been found in the State.

The magnetite and ilmenite may find a use in the manufacture of magnetite electrodes that are manufactured by the General Electric Company.

The garnet grains are sharp and can be used for abrasive purposes in the manufacture of garnet paper, which is used extensively in the boot and shoe trade.

THE OPTICAL ROTATION OF SPIRITS OF TURPENTINE*

BY CHAS. H. HERTY

Among the physical properties of spirits of turpentine, none has proved of more interest than its optical rotation. In most specimens this property is very marked, and as the liquid is colorless and the determination readily made, many data are found on this subject in chemical literature. Slight variations in the rotation of different samples are to be expected, as spirits of turpentine is not a chemical compound but a mixture of substances, chiefly terpenes. From the results of numerous observations upon commercial samples, the view commonly held previous to 1891 was that French spirits of turpentine, distilled from the oleoresin of *Pinus maritima*, is levo-rotatory and that American spirits of turpentine, distilled in years past, almost wholy from *Pinus palustres*, is dextro-rotatory. The difference in the character of the rotation was ascribed, therefore, to the different species from which the spirits of turpentine was produced.

Recognizing the fact that American spirits of turpentine is distilled from more than one species of pine, J. H. Long,[1] in 1891, undertook a study of the volatile oils distilled from oleoresins of well identified individual trees, these trees embracing the several species of pines subjected to turpentining in our southern states. He found that specimens from *Pinus palustris* (Long Leaf Pine) gave dextro-rotatory oils, while those from *Pinus heterophylla* (Cuban or Slash Pine) gave levo-rotatory oils. Since the oleoresins from these two species are indiscriminately mixed, at the time of collection in the woods, the rotation of the oil distilled from such a mixture would naturally vary. *Pinus palustris* is the

*Reprinted from the Journal of the American Chemical Society, vol. 30, p. 863.

[1] *J. Anal. Appl. Chem.*, 6, 1.

predominating species and Long attributed to this fact the dextrorotatory character of American spirits of turpentine. This view has been generally accepted.

The fact that spirits of turpentine is frequently adulterated with optically inactive mineral oil, led A. McGill[2] to make a large number of determinations of the rotation of commercial samples of spirits of turpentine, in the hope of utilizing this property for the detection of adulteration. From the widely varying results obtained he was compelled to declare the method useless.

New evidence upon this point has been obtained from investigations carried on in this laboratory in collaboration with the U. S. Forest Service, the experimental work having been carried out by Messrs. George A. Johnston and W. S. Dickson under the direction of the writer. In order to gain a better knowledge of the oleoresins from the two principal species of pine utilized in the turpentine industry at the present time, fourteen trees were selected on a Florida turpentine farm. One-half of these were *Pinus palustris*, the other half *Pinus heterophylla*. Three trees of each species were tapped for the first time at the beginning of the experiments. In each case a small, young pine, a medium pine, and a large, old pine were selected. In another set four trees were selected, two each *Pinus palustris* and *Pinus heterophylla*. These trees had been subjected to turpentining during the previous year, the chipping or weekly scarification, on all of them having been unusually shallow, only about one-half as deep as is commonly practiced. In a third set four trees were selected, two of each of *Pinus palustris* and *Pinus heterophylla*, which had been turpentined during the previous year, and on each of these the depth of the chipping was the normal cut. The trees in each set were chipped at intervals of seven days.

Special precautions were taken in the collection of the oleoresins. The cup and gutter system described in *Bulletin No. 40, U. S. Bureau of Forestry*, was used. Instead of the clay cup commonly used, oyster pails were substituted. The entire apparatus was covered with black oilcloth fastened securely into the bark of the tree above the chipping surface, thereby protecting the resin

---

2 *Bulletin No. 79, Inland Revenue Dept., Canada.*

from light and avoiding the filling of the pails with rain water. Every four weeks these pails were removed from the tree, tightly stoppered and immediately shipped to this laboratory for examination. The specimens so obtained were extremely pure and free from chips. After removal of the pails, the metal gutters were raised to a point near the shipping surface in order to minimize the amount of oleoresin which might stick to the exposed portion of the trunk above the gutters.

The distillation of the oleoresins was carried out in a 500 cc. Kjeldahl flask, surrounded by a bath of cottonseed oil. Steam from a small boiler was first passed through a small iron pipe in which it could be superheated, then into the distillation flask through a glass tube having on its end a bulb containing a number of openings. By this means strong agitation of the molten oleoresin was obtained. Thermometers were placed both inside the flask and in the oil-bath. The mixed vapors of steam and spirits of turpentine were passed through a Hopkins condensing bulb to prevent the carrying over of solid particles of resin, condensed in an ordinary Liebig condenser and collected in a separatory funnel. After drawing off the lower layer of water, the spirits of turpentine was transferred to a dry flask and allowed to stand over night with calcium chloride. The determinations of the optical rotation of the volatile oils were made with a Schmidt and Haensch half-shadow polariscope, sodium flame, at 20°.

In the following table are given the results from the first collection of the oleoresin in early spring:

TABLE I

Tree designation	Species	Diameter (inches)	Character of chipping	Optical rotation 100 mm tube, 20 C
A1	*P. heterophylla*......	7.0	1st year, normal depth	—20°50′
A2	"	14.5	" "	+ 0°15′
A3	"	24.5	" "	—15° 0′
A4	P. *Palustris*.........	7.3	" "	+15°40′
A5	"	15.0	" "	+ 8° 9′
A6	"	21.0	" "	+18°18′
C1	*P. heterophylla*......	12.3	2nd year, shallow	—27°11′
C2	"	8.2	" "	—26°28′
C3	*P. palustris*..........	13.0	" "	— 7°26′
C4	"	8.7	" "	+ 7°31′
D1	"	9.0	2nd year, normal depth	+10°50′
D2	"	13.5	" "	+ 1°23′
D3	*P. heterophylla*......	13.0	" "	—18°35′
D4	"	9.0	" "	—29°26′

These results show a wide variation in the optical rotation of the volatile oils from the individual trees, even among trees of the same species. In a general way the figures give support to Long's view, namely that the volatile oils from *Pinus palustris* are dextro-rotatory and those from *Pinus heterophylla* levo-rotatory. That this is not strictly true, however, is evidenced by the dextro-rotation of A_2 (*P. heterophylla*) and more especially by the levo-rotation of C_3 (*P. palustris*).

With these variations in the first collection from the several trees, the question naturally arose, would the variations change as the season advanced or would the figures prove constant for the individual trees? The rotations for the successive collections follow in Table II:

TABLE II.—OPTICAL ROTATION IN 100 MM. TUBE, 20° C.

Collection	A1	A2	A3	A4	A5	A6	C1
1..	—20°50′	+0°15′	—15° 0	+15°40′	+8° 9′	+18°18′	—27°11′
2..	—22° 5′	—0°30′	—14°26′	+15°22′	+8°50′	+17°43′	—26°48′
3..	—21°45′	+0°15′	—15°55′	+14°15′	+8°27′	+19°30′	—26°25′
4..	—21° 7′	—1°15′	—15°50′	+14°20′	+8°34′	+18°46′	—23°32′
5..	—20°30′	—2° 5′	—15°15′	+14°21′	—8°32′	+19°24′	—21°12′
6..	—20°15′	—3°30′	—15°27′	+14°35′	+8° 4′	+18°16′	—21°46′
7..	—22°15′	—5°45′	—17°52′	—12°49′	+7° 6′	+14°47′	—21°35′

Collection	C2	C3	C4	D1	D2	D3	D4
1..	—26°28′	—7°26′	+ 7°31′	+10°50′	+1°23′	—18°35′	—29°26′
2..	—25°37′	—6°42′	+ 7°20′	+11°23′	+2°40′	—17° 0′	—27°45′
3..	—26°20′	—4°45′	....	+13° 7′	+2°25′	—15°20′	—28°19′
4..	—26°30′	—4°29′	....	+12°46′	+2°25′	—15° 0′	—27°38′
5..	—26° 7′	—3°55′	....	+13° 0′	+1°13′	—14°38′	—27°48′
6..	—26° 0′	—4° 5′	....	+13° 0′	+1°15′	—14° 7′	—26°11′
7..	—26°28′	—6° 6′	....	+10°48′	—0°55′	—14°19′	—26°12′

NOTE.—The yield of oleoresin from C4 was so small, after the first and second collections, that not enough volatile oil could be obtained on distillation to fill the 100 mm tube.

From this table it is seen that the rotation in most cases is quite constant throughout the year. The most marked exception is A_2 (*P. heterophylla*). It is evident that some distinct change in the biological activity of this tree has taken place, for while the rotation is reasonably constant during the first half of the year, a steady increase in the levo-character of the oil is apparent during the last half. In the case of C_1 (likewise *P. heterophylla*) some-

what the reverse has taken place. A rather marked decrease in the levo-rotation is shown just at the middle of the year, then the rotation remains practically constant during the last half. In the case of C_3, another type of change is represented, the levo-rotation decreasig up to the middle of the season and again increasing during the latter half.

With the limited facts at hand, it is impossible to interpret the significance of these changes. That tree which shows the most marked variation, A_2, is a healthy, vigorous tree, from which variations would be least expected. Nor can an explanation be offered for the wide variations in the optical rotation of oils from the same spieces. All of the trees in Series A are located within 20 yards of each other and have, therefore, the same general conditions of climate, light and soil. Fractionation of the volatile oils from these show practically the same rise in boiling-point for the same volume of distillate. It would seem, therefore, that these volatile oils, consisting so largely of pinene, are mixtures principally of dextro- and levo-pinene, the preponderance of the one or the other determining the optical rotation.

UNIVERSITY OF NORTH CAROLINA,
CHAPEL HILL, N. C.

THE CHARACTER OF THE COMPOUND FORMED BY THE ADDITION OF AMMONIA TO ETHYL-PHOSPHO-PLATINO-CHDORIDE*

BY CHAS. H. HERTY AND R. O. E. DAVIS

By heating together phosphorus pentachloride and spongy platinum, Baudrimont[1] obtained the phospho-platino-chloride $PtCl_2$-.PCl_3. Later Schutzenberger[2] prepared the compound $PtCl_2.2PCl_3$ by treating Baudrimont's salt with phosphorus trichloride and he studied the various derivatives of these two substances.

The apparent analogy of these compounds to those of platinous chloride with ammonia led one of us (Herty) in 1901 to investigate them further by physico-chemical methods, in order to determine whether the analogy was real and therefore whether they conformed to Werner's[3] extension of the valence hypothesis. If so, various possibilities of isomerism at once suggested themselves.

These views, in abstract form, were presented to the committee in charge of the C. M. Warren Research Fund and a grant was made for the purchase of platinum. Work was begun at once, but unfortunately a call to another field made impossible the completion of the investigation. The platinum was recovered, sold, and the grant returned.

1 *Ann. chim. phys.* [4], 2, 47.
2 *Bull. soc. chim.* [2], 17, 482; 18, 101, 148.
3 *Z. anorg. Chim.*, 3, 267.
4 *Ibid.*, 37, 394; 43, 34.

*Reprinted from the Journal of the American Chemical Society, Vol. 30, p. 1084. 1908.

Later, Rosenheim[4] published the results of an investigation covering practically the same ground. He found that the analogy was real and succeeded in obtaining numerous isomers. With the stable ethoxy derivatives, molecular weight determinations, both ebullioscopic and cryoscopic, showed that while the formula of the 1 : 2 compound is normal, that of the 1 : 1 compound must be doubled, thus

$$PtCl_2.2P(OC_2H_5)_3 \text{ and } (PtCl_2.P(OC_2H_5)_3)_2.$$

These facts show both compounds in strict accord with Werner's coordination ideas, namely, that the coordination number of platinum in platinous compounds is four. Accordingly, their formulas would be

$$\left\{ Pt \begin{matrix} Cl_2 \\ [P(OC_2H_5)_3]_2 \end{matrix} \right\} \quad \text{and} \quad \begin{matrix} \left\{ Pt \begin{matrix} Cl_2 \\ P(OC_2H_5)_3 \end{matrix} \right\} \\ | \\ \left\{ Pt \begin{matrix} Cl_2 \\ P(OC_2H_5)_3 \end{matrix} \right\} \end{matrix}$$

The addition of one molecule of aniline to the former, results in one chlorine atom becoming ionizable, but from the latter, Rosenheim succeeded in obtaining two isomeric substances, a white and yellow modification, each having the formula

$$\left\{ Pt \begin{matrix} Cl_2 \\ P(OC_2H_5)_3 \\ C_6H_5NH_2 \end{matrix} \right\}$$

again conforming to Werner's views.

However, when gaseous ammonia was used instead of aniline an unexpected result was obtained. Two molecules of the base were added for each atom of platinum present, the empirical formula being $PtCl_2.P(OC_2H_5)_3.2NH_3$. According to Werner's views, such a compound should be diionic, as represented by the formula

$$\left\{ \begin{matrix} Cl \\ Pt(NH_3)_2 \\ P(OC_2H_5)_3 \end{matrix} \right\} Cl.$$

But Rosenheim found that silver nitrate precipitated at once both chlorine atoms, even at 0°, and that the molecular conductivity at 25° was

ν	32	64	128	256	512
μ	155.9	160.8	160.4	160	162.3

From these facts and from the composition of the double salt with chlorplatinic acid, he concluded that the formula may be

$$\left\{ Pt \begin{matrix} (NH_3)_2 \\ P(OC_2H_5)_3 \end{matrix} \right\} Cl_2,$$

but since such a formula is not in accord with the coordination number of platinous platinum, and since the compound is derived from the double molecule

$$\left\{ Pt \begin{matrix} Cl_2 \\ P(OC_2H_5)_3 \end{matrix} \right\}_2$$

Rosenheim assigned to it the formula

$$\left\{ Pt \begin{matrix} (NH_3)_2 \\ P(OC_2H_5)_3 \end{matrix} \right\}_2 Cl_4.$$

Such a formula appeared to us to be a strained interpretation of Werner's views. Furthermore, the molecular conductivity, as given by Rosenheim, is abnormal in every way. It seemed desirable, therefore, to repeat the preparation of the substance and to study its properties further. Experience gained in the study of the molecular conductivity of complex ammonia compounds at 0°[1]

1 Werner and Herty, Z. *phys. Chem.* vol. 38, p. 331.

justified the hope that such a study of this compound might throw more light upon its constitution. Following the directions of Schutzenberger and of Rosenheim, pure spongy platinum was heated with phosphorus pentachloride, the latter freed from trichloride and oxychloride by heating in a current of dry air at 110°. The fused mass on treatment with hot benzene, free from thiophene and purified by freezing, yielded on cooling an abundant crop of well crystallized

$$\left\{ Pt \begin{matrix} Cl_2 \\ PCl_3 \end{matrix} \right\}$$

Freed from benzene, at the same time carefully protected from the action of moisture, the compound wos immediately treated with absolute alcohol in order to convert it into the ethoxy derivative

$$\left\{ Pt \begin{matrix} Cl_2 \\ P(OC_2H_5)_3 \end{matrix} \right\}_2 .$$

The alcoholic solution was then placed in a desiccator over two vessels, one containing concentrated sulphuric acid, the other powdered lime, and left to evaporate to crystallization. Removal to a new building necessitated cessation of the work for several months. On resuming, it was found that the solution in the desiccator had evaporated to dryness, no distinct crystallization being noticeable. This mass was dissolved in pure benzene and into the solution dry ammonia gas was conducted. The absorption of ammonia was accompanied by a marked elevation of temperature, the original yellowish tint of the solution gradually faded and then, rather suddenly, a mass of white crystals separated, the mass becoming almost solid. The completion of the reaction was indicated by the return to normal temperature. The crystal broth was set aside and owing to the exigiencies of other work, two weeks elapsed before the crystals were separated from their mother liquor. The substance, freed from benzene, was recrystallized from alcohol and obtained in a very pure form.

A portion of the substance dissolved in water showed no acid reaction, although Rosenheim found an immediate acid reaction and explained the peculiar results he obtained from a study of its molecular conductivity by assuming a rapid hydrolysis of the compound. Analysis showed:

			Found by Rosenheim	
	I	II	I	II
Cl (Ionizable).........	8.02	7.96	15.08	14.42
Pt.........................	42.30	41.40	41.68	......
NH_3	7.04	7.18	7.19	......

	Theoretical for	
	$\left[Pt\begin{matrix}(NH_3)_2\\ P(OC_2H_5)_3\end{matrix}\right]_2 Cl_4$	$\left[Pt\begin{matrix}Cl\\ (NH_3)_2\\ P(OC_2H_5)_3\end{matrix}\right] Cl$
Cl (Ionizable)..................	15.23	7.62
Pt	41.82	41.82
NH_3	7.30	7.30

Ionizable chlorine was determined at room temperature by precipitation of the water solution of the substance with excess of silver nitrate. The filtrates remained clear even after standing several weeks. Platinum was determined by Rosenheim's method[1], ammonia by the Kjeldahl method.

Effort was then made to determine the total chlorine by Rosenheim's method[1] but concordant results could not be obtained. Determinatians of the total chlorine by Stepanow's[2] method gave:

Total Chlorine		
I.	II.	Theoretical
15.19	15.00	15.23

Determination of the molecular conductivity at 25° showed

v	32	64	128	256	512	1024	2048
μ..........................	95.79	100.13	106.09	113.49	119.70	127.97	138.98
Found by Rosenheim	155.9	160.8	160.4	160.0	162.3	......	......

[1] *Z. anorg. Chem.*, Vol. 37, p. 395.
[2] *Ber.*, Vol. 39, p. 4056.

The values for μ found by us agree closely with the figures obtained by Werner and Miolati[3] and by Werner and Herty[4] for all diionic complex ammonia compounds. No evidence of hydrolysis could be detected in the solution which had been used for the determination of the molecular conductivity, the reaction was perfectly neutral.

From all the above facts, it is evident that the formula of our compound is

$$\left\{ Pt \begin{matrix} Cl \\ (NH_3)_2 \\ P(OC_2H_5)_3 \end{matrix} \right\} Cl,$$

a formula strictly in accord with Werner's coordination law. It would seem further that we have here another case of isomerism of inorganic compounds.

In order to gain further knhwledge of the conditions which determine the formation of the one or the other of these substances, new experiments were begun. A fresh portion of the compound

$$\left\{ Pt \begin{matrix} Cl_2 \\ P(OC_2H_5)_3 \end{matrix} \right\}_2$$

was prepared. Twenty-one grams of the substance were dissolved in seventy-five cc. of benzene and the solution was divided into three equal portions. In one, designated A, the substance was prepared under the conditions above described. In another, designated B, the crystals were promptly separated from the benzene liquor. In the third portion, designated C, the temperature was maintained at 6° throughout the experiment.

In order to insure as far as practicable a uniform addition of ammonia in the several experiments, thirty-five grams each of finely pulverized lime and ammonium chloride were thoroughly mixed and placed in a 500 cc. round bottom flask and heated in a

---

[3] *Z. phys. Chem.*, Vol. 12, p. 35; Vol. 14, p. 506; Vol. 21, p. 225.
[4] *Ibid.*, Vol. 38, p. 331.

bath of cottonseed oil. At 220° copious evolution of ammonia began. The gas, dried over quicklime, was passed through the benzene solution of the ethoxy compound for forty-five minutes, during which time the temperature of the oil bath was gradually raised to 245°.

The benzene solution was placed in a 50 cc. round bottom flask provided with a three-hole rubber stopper through which passed a thermometer dipping into the solution and the inlet and outlet tubes for the ammonia.

Experiment A: The initial temperature of the benzene solution was 22°. When the temperature of the oil bath surrounding the generator reached 220° the temperature in the absorption flask began to rise. After five minutes it was 25°, after ten minutes 33°, after fifteen minutes, 38°. Meanwhile the yellow color of the original solution gradually faded. After twenty minutes the tempetature was 40°, then suddenly the separation of the white substance took place to such an extent that the mass became almost solid. A portion of the substance was at once removed from the absorption flask, pressed between folds of drying paper and dissolved in water. No evidence of hydrolysis could be detected, the solution being perfectly neutral to indicators, As Rosenheim found that his salt was strongly hydrolyzed, it was decided to continue the passage of the ammonia gas into the crystal broth longer. Accordingly, this was continued for twenty-five minutes more, the temperature of the solution falling gradually. The vessel tightly corked was allowed to stand two weeks. At the end of this time the crystals were filtered from the benzene and pressed between folds of drying paper, then recrystallized from absolute alcohol and labeled "A".

Experiment B: This was a repetition of Experiment A except that the crystals were removed from the benzene immediately after the conclusion of the experiment. The maximum temperature observed in the absorption flask was 44°. The separation of the crystals took place twenty-two minutes after the temperature of the oil bath surrounding the ammonia generator had reached 220°. The substance recrystallized from alcohol was labeled "B".

Experiment C: This was a repetition of Experiment B except that the temperature of the benzene solution was kept constantly at 6°. The crystal separation took place twenty-four minutes from the time the oil bath reached 220°. Recrystallized from alcohol the substance was labeled "C".

The results of the analyses of the three preparations follow:

	Ionizable chlorine I	Ionizable chlorine II	Total Chlorine	Theoretical chlorine for $\left[\begin{matrix}Cl\\ Pt\,(NH_3)_2\\ P(OC_2H_5)_3\end{matrix}\right]Cl.$ Ionizable	Total
A	7.66	7.64	15.16	7.62	15.23
B	7.74	7.66	15.17	......	......
C	7.47	7.49	15.01	......	......

From these results it is evident that we have succeeded in preparing only the normal salt

$$\left\{\begin{matrix}Cl\\ Pt\,(NH_3)_2\\ P(OC_2H_5)_3\end{matrix}\right\}Cl.$$

And yet Rosenheim's directions have been faithfully followed and his description of the absorption experiment coincides with our observations. It is therefore not considered profitable to further undertake the preparation of Rosenheim's compound until more specific directions are given. Meanwhile, it is our intention to try to prepare the compound

$$\left\{\begin{matrix}Cl_2\\ Pt\,NH_3\\ P(OC_2H_5)_3\end{matrix}\right\}$$

analogous to the aniline compound prepared by Rosenheim, and to gain further light upon the character of the reaction by which the addition of ammonia changes the non-ionizable compound

$$\left\{\begin{matrix}Cl_2\\ Pt\\ P(OC_2H_5)_3\end{matrix}\right\}_2$$

into the ionizable compound

$$\left\{ \begin{matrix} \mathrm{Cl} \\ \mathrm{Pt}\ (\mathrm{NH_3})_2 \\ \mathrm{P(OC_2H_5)_3} \end{matrix} \right\} \mathrm{Cl}.$$

UNIVERSITY OF NORTH CAROLINA
CHAPEL HILL, N. C.
March 11, 1908

THE VOLATILE OIL OF PINUS SEROTINA*

BY CHAS. H. HERTY AND W. S. DICKSON

Scattered among the forests of Long Leaf pine along the Atlantic seaboard, there are found, usually in mixed stands, patches of Pond pine (*Pinus serotina*) and Loblolly pine (*Pinus taeda*). These pines are seldom subjected to turpentining, as the yield of oleoresin is not so plentiful as from the predominating types *Pinus palustris* and *Pinus heterophylla*. Nor are the two species usually distinguished locally, the name "black pine" being applied to each. The striking odor of the wood of *Pinus serotina* when freshly cut made desirable an investigation of its volatile oil, and in collaboration with the U. S. Forest Service, the oil has been studied in this laboratory during the past year. Well identified trees were selected in Florida. The trees were regularly chipped throughout one season of eight months. The product from each tree was collected every eight weeks. The oleoresin closely resembles that from Cuban pine (*P. heterophylla*) being quite liquid and containing relatively about the same proportion of crystalline acids. To this low percentage of crystalline matter is to be assigned doubtless, as in the case of *P. heterophylla*, the absence of "scrape" formation on the scarified surface of the tree, a formation so typical of *P. palustris*).

The volatile oil was distilled from the oleoresin by steam in the apparatus described on page 865 above. The oleoresin evidently contains a greater portion of mucilaginous substances than that from the more common pines, for it was much more difficult to distil. On heating to 140°, the usual temperature of distillation, and introducing steam, the easily molten mass froths badly. This could be avoided only by raising the temperature at the out-

*Reprinted from the Journal of the American Chemical Society. Vol. 30, p. 872. May, 1908.

set to 160°. At this temperature, the viscosity is diminished sufficiently to enable a complete distillation to be carried out without frothing. During the latter part of the summer, however, and during the autumn, the amount of this mucilaginous substance evidently increased, and to such an extent that it became practically impossible to distil off the volatile oil. Partial success was secured by he addition of concentrated sodium hydroxide solution to the distilling flask.

The resin left after distillation is pale yellow, similar to the best grades of commercial resin. Acid number 167.

The volatile oil, freed from water by standing in contact with calcium chloride, was a limpid liquid with a fragrant odor suggesting at once the presence of limonene. The physical constants of the oil follow:

Sp. gr.: 20°, 0.8478.
Sp. rotation: 20°, —105°36.
Index of refraction: 20°, 1.4734.
Acid number: 0.
Saponification number: 1.54.
Iodine number: 378.
Solubility in ethyl alcohol at 22.5°:
95 per cent. alcohol 1.35 parts required to dissolve 1 part of volatile oil.
90 per cent. alcohol 4.80 parts required to dissolve 1 part of volatile oil.
85 per cent. alcohol 8.10 parts required to dissolve 1 part of volatile oil.
80 per cent. alcohol 16.20 parts required to dissolve 1 part of volatile oil.
70 per cent. alcohol 56.00 parts required to dissolve 1 part of volatile oil.

Comparative evaporation with the volatile oil of *P. palustris*, at room temperature, in shallow watch glasses, 0.2 gram of each used.

Time	P. palustris Per cent.	P. serotina Per cent.
Loss after ½ hour	35.7	20.30
Loss after 1 hour	62.5	37.30
Loss after 1½ hours	91.7	53.40
Loss after 2 hours	96.0	68.47
Loss after 5 hours	97.8	98.80

On fractionation the following results were obtained:

Temperature	Per cent. distillate	Index of refraction, 20°	Rotation in 100 mm. tube 20°
172-175°	27.4	1.4716	—87°53'
175-180°	57.0	1.4724	—92°21'
180-185°	8.4	1.4744	—92°14'
185-+	7.2	1.5045	....

Repeated fractionation at atmospheric pressure showed some polymerization. From a fraction, 175-176°, a large yield of limonene tetrabromide was obtained. Melting point 103°-103°. The solution of the tetrabromide in chloroform was levo-rotatory, — 70-0°.

A study of the oxygen absorbing power of this volatile oil in comparison with that of the ordinary spirits of turpentine obtained from *P. palustvis* showed a much larger absorption by the oil of *P. serotina* during the early days of the experiment, but the total absorption after three months' exposure to northern light was practically the same in each.

These results show a wide variation in the optical rotation of the volatile oils from the individual trees, even among trees of the same species. In a general way the figures give support to Long's view, namely that the volatile oils from the *Pinus palustris* are dextro-rotatory and those from *Pinus heterophylla* levo-rotatory. That this is not strictly true, however, is evidenced by the dextro-rotation of A_2 (*P. heterphylla*) and more especially by the levo-rotation of C_3 (*P. palustris*).

UNIVERSITY OF NORTH CAROLINA
CHAPEL HILL, N. C.

MICROPEGMATITE AT CHAPEL HILL.

BY H. N. EATON.

During the course of an investigation of the Chapel Hill granites now in progress an occurrence of micropegmatite was discovered which seems worthy of special mention. The binary granites were found to contain micrographic intergrowths of quartz and feldspar. The one showing the best development of this phenomenon is described below.

This rock occurs in a slightly weathered condition just beyond the village limits on the slope of the hill along the Hillsboro road and south of Bolin's Creek. Its extent and relation to the other rocks of the igneous complex of the region are unknown.

In handspecimen, the rock is grayish pink in color, and fine grained. No hint of the arrangement of the minerals is given from a freshly broken surface owing the uniform fineness of grain.

In thin section, the mineral content is seen to comprise plagioclase, orthoclase, microcline, and some accessory magnetite. The striking feature of the slide is the arrangement of the quartz and alkali feldspar in the micropegmatitic relation.

With the exception of the magnetite, plagioclase was the first mineral to crystallize. It occurs sparingly in short, stout prisms, for the most part idiomorphic, but in places showing absorption by the later formed minerals. Twinning occurs after both the carlsbad and albite laws. Owing to strong kaolinization the albite striations are frequently difficult to recognize. The maximum extinction angle noted was 13 degrees, thus placing the species between oligoclase and andesine, and nearer the latter of the two.

Quartz and alkali feldspar occur mutually inclosing and interpenetrating each other in micrographic intergrowths. The

quartz is best seen in this relation in long, spindle-shaped forms with parallel orientiation over a considerable portion of the field. These are wholly inclosed in orthoclase or microcline and extinguish simultaneously over wide areas. Measurements with a micrometer eye-piece gave lengths of .58 m.m., .62 m.m., and .69 m.m. for the longer quartz spindles. In places the large spindles radiate from centers in which clusters of smaller quartz crystals are imbedded in orthoclase and microcline. There are a few places where quartz occurs in the triangular and knee-shaped form characteristic of graphic granite as originally described.

The orthoclase is very abundant and forms a large percentage of the rock. Crystal boundaries are very indistinct. Large areas inclosing the quartz spindles extinguish as single crystals separately from the quartz.

Microcline is less abundant than orthoclase, and the areas occupied are smaller. Crystal boundaries are indistinct.

The impression first given by the slide is that the orthoclase and microcline were the last to crystallize, and constitute a groundmass in which the quartz is set, but a careful examination reveals many quartz-feldspar boundaries in which the two minerals are mutually interpenetrating. Many quartzes also contain small poikilitic inclusions of orthoclase. It is therefore probable that the quartz and the alkali feldspars crystallized contemporaneously.

UNIVERSITY OF NORTH CAROLINA
CHAPEL HILL, N. C.
March 11, 1908

ABSTRACTS

On the Effect of Complete Anemia of the Central Nervous System in Dogs Resuscitated after Relative Death. D. H. Dolley and George Crile, M. D.[1] Jour. of Expe. Med., vol. 10, Nov. 1908.

This study of brain anemia is the sequence of provious work on the resuscitation of animals killed by anaesthetics and asphyxia,[2] which may be briefly summarized as follows: By measn of a centripetal arterial infusion of salt solution under sufficient pressure, together with the injection of one to two cubic centimeters of 1-1,000 adrenalin chloride in mass dose early and along with the infusion, and the simultaneous employment of vigorous artificial respiration and gentle but firm cardiac massage through the unopened thorax, a heart which has ceased to beat may be excited to resume beating within certain limits. Up to five minutes of total cessation of function, these efforts are uniformly and readily successful, provided that the full technique has been used: up to ten minutes, there is an occasional failure, but after that the chances of success become progressively less. Our limit was five minutes in puppies (three cases).

To determine the limits of recovery after the total anemia of the central nervous system incident to a state of relative death, a series of thirty dogs was killed by chloroform and resuscitated after varying times from three to fourteen minutes. Under five minutes the recovery of function was rapid and strikingly free from the after effects which characterized longer periods. Of seven animals between the periods of five minutes and six and one half

[1]From the Laboratory of Surgical Physiology, Western Reserve University, and the Pathological Laboratory, University of North Carolina.

[2]*Jour. of Exper. Med.*, vol. 18, p. 718, 1906.

minutes, only one died apparently as a direct result of the anemia, but of twelve between the periods of seven minutes and eight and one half minutes, only one, after seven and one half minutes, recovered. The remaining dogs all died.

After a resuscitation, the course of events in the animals which succumbed, while limited according to the extent of the reanimation, was similar to that in the dogs which did eventually recover. Many of the dogs showed more than a mere reflex revival there being some temporary manifestation of special senses and higher faculties in addition. In general, three stages were to be observed. A state of hyperexcitability followed reanimation, reaching its maximum in one to three hours, when retrogression began. This second stage was characterized by the onset of uncontrolled muscular movements, either coordinate or convulsive, lasted a longer time, and gradually passed into the third stage of depression and paralysis. The crisis in practically all the experiments was reached in from twelve to twenty-four hours. Then death quickly ensued or distinct improvement of nervous functions shortly began, continuing more or less rapidly till complete restoration, though the convalescent period lasted in two dogs four and six weeks respectively. There was no intermediate condition of fatal outcome delayed for several days except in several cases in which death was due to accidental organic lesion. Up to a certain point, not to be exactly limited, but roughly six minutes, the after effects were not marked, and the second, third, or fourth day brought complete recovery. Beyond the six minute limit, however, there was a great deal of after effect, increasing out of all proportion to the increase in the duration of the period of anemia, reaching as well in the dogs which finally recovered a temporary state in which the animal was little more than a cardio-respiratory mechanism.

(The sequence of return of the various functions and reflexes and the special phenomena following a resuscitation are discussed in detail.)

Histological examination both of presumptive recoveries and fatal cases was made by ordinary methods and those of Nissl and Marchi. The neurocytes of the fatal cases uniformly presented the greatest change, not merely chromolytic but here and there

indicative of cell death. Marchi's method further supported these findings by proving the existence of fibre degeneration. Finally, showing the narrowness of the escape, the best result in recovery, seven and one half minutes in time, which at the end of four weeks had apparently entirely returned to a normal state, by the Marchi method had a degeneration of a number of fibres localized in the pyramidal fasciculi, which were traced from the cord to the cortex, and in Flechsig's fasciculus, as well as a more sparsely scattered degeneration of both ascending and descending fibres elsewhere. The results of the histological examination place the limits of experimental resuscitation upon an anatomical basis.

CONCLUSIONS

1. In dogs anesthetized by ether for preparation and killed quickly by chloroform, the average limit of total cerebral anemia, estimated from the cessation of the heart sounds to the return of circulation, which admits of recovery, is between six and seven minutes. Any recovery beyond seven and half minutes would be exceptional, and the ulterior limit appears to be under ten minutes, hitherto stated as the most conservative figure after other modes of investigation.

2. Further, experience with resuscitation of animals killed by anesthetics and asphyxia, embracing numerous unrecorded experiments as well as those forming the basis of the present article, establishes our former conclusion, that the procedures detailed afford a reliable method within its limitations, and certainly uniformly successful within the limits compatible with the recovery of the central nervous system.

BINDERS FOR COAL BRIQUETS, by J. E. Mills. Bulletin 343 of the United States Geological Survey.

The bulletin contains a report of investigations made at the Fuel-Testing Plant, St. Louis, Mo., by the author. The characteristics of good briquets are discussed and the general conditions governing the use of binders. A very large number of different binders were investigated in the laboratory, the effort having been made to include in the list all binders which it was thought

might be used commercially in the United States, as well as certain other substances which seemed fitted to throw light on the laws governing the action of the binder. Attempt was also made to study such modifications and combinations of the different binders as it seemed might produce more efficient commercial results. The author gives the following summary of the investigations:

"Definite answer to the question 'What is the best binder to use in making briquets?' depends, as repeatedly emphasized in this paper on the locality, on the character of the coal, and on the purpose for which the briquets are intended. For purposes of a brief comparison consideration is given to the binders available for a coal which is fairly easy to briquet and which cakes rather readily. A few coals will briquet with somewhat less and others require greater percentages of binder, but an endeavor has been made in the following summary to strike a reasonable average.

"The experiments herein reported show that, in general, for plants situated where it can be obtained, the cheapest binder will prove to be the heavy residuum from petroleum, often known to the trade as asphalt. Four per cent of this binder being sufficient, its cost ranges from 45 to 60 cents per ton of briquets produced. This binder is particularly available in California, Texas, and adjacent territory.

"Second in order of importance comes water-gas tar pitch. Five to six per cent usually proving sufficient, the cost of this binder ranges from 50 to 60 cents per ton of briquets produced. As water-gas pitch is also derived from petroleum, it will be available more particularly in oil-producing regions.

"Third in order of importance is coal-tar pitch. Being derived from coal, this binder is very widely available. From 6.5 to 8 per cent will usually be required, and the cost ranges from 65 to 90 cents per ton of briquets produced.

"Of local importance, where the price permits, are natural asphalts and tars derived from wood distillation. The price of each of these binders varies greatly with the locality, but there are doubtless places where they could compete with the binders

above mentioned. Wax tailings could be used with an easily caking coal.

"Pitch made from producer-gas tar is not yet on the market, but it will produce excellent briquets with a lower percentage of binder than other coal-tar pitches. It will doubtless be available in the future.

"Briquets excellent in all respects except that they are not waterproof can be made by using 1 per cent of starch as a binder, the cost of which is 20 cents per ton of briquets produced. Extra care is necessary in drying and handling these briquets, and this adds to their cost.

"The waste sulphite liquor from paper mills also producees excellent briquets except that they are not waterproof. At present it is a troublesome waste product dissolved in much water. Its utilization for this purpose will bear further investigation.

"Of inorganic binders, magnesia might be utilized, as its probable cost would not exceed 22 to 30 cents per ton of briquets produced. Other inorganic binders, while available as regards price, would not make first-class briquets.

"The briquetting of lignite coal offers a peculiarly difficult problem. If the lignite cakes in the fire, asphaltic residues from petroleum or water-gas tar pitch may be used as binder, larger percentages being required than for ordinary coals. The most promising binders for lignites that do not cake are starch, sulphite liquor, and magnesia. Lignites may be briquetted without binder if they are to be burned on grates specially constructed to overcome the tendency to fall to pieces in the fire.

"Attention is called to the suggested method of deciding as to the value of coal-tar pitch for briquetting purposes. The method is likewise applicable to asphalts and petroleum residues generally; (1) The pitch or tar is distilled and all oils coming off below 270° C. are rejected as being of no value; (2) the flowing point of the portion to be used in briquetting is determined (this should generally not be less than 70° C.) (3) the pitch is extracted with carbon disulphide. The smaller the amount of residual carbon the more satisfactory is the pitch. The less readily the coal cakes the higher must be the flowing point of the pitch. If a pitch cracker is used, the pitch to work successfully

on a hot summer's day must have a flowing point above 120° C. In the winter pitch with a flowing point of 100° C. may be used. All softer pitches and asphalts have to be melted and mixed in liquid form with the coal.

A pitch with a very high softening point, above 150° C., should be either thinned or superheated in the mixer. The efficient use of a binder depends very largely on the proper regulation of the conditions in the mixer. The presence of low-volatile compounds in the pitch to be used as a binder increases the smoke in burning; and also increases the tendency of the briquet to soften and crack open in advance of combustion, owing to the volatilization and escape of these compounds.

"The main problem in briquetting is to find a suitable binding material at sufficiently low cost. When the difference in price between the slack coal and the first-class lump coal is $1. the cost of briquetting should not exceed this amount. Of this the binder must cost less than 60 cents per ton, as the cost of manufacture averages about 40 cents. To leave out of consideration the possible advantages in the use of briquetted coal over run-of-mine coal, due to the greater efficiency and smokelessness of briquets, it will probably not be necessary to pay any attention to binding materials costing $1.25 or more per ton of briquets produced."

THE VOLATILE OIL OF PINUS SEROTINA, by Chas. H. Herty and W. S. Dickson. Jour. Am. Chem. Soc., vol. 30, p. 872. May 1908.

A study of the volatile oil obtained by distillation with steam from the oleo-resin of Pinus Serotina (Pond Pine) showed that it contained large quantities of limonene instead of the more common pinene present in ordinary spirits of turpentine. The oil showed the following physical contents:

Specific Gravity: 20° 0.8478
Specific Rotation: 20° —105° 36'
Index of Refraction: 20° 1.4734
Acid Number: 0
Saponification Number: 1.54
Iodine Number: 378
On Fractionation the oil showed:

Temperatures	Per Cent of Distillate
172-175	27.4
175-180	57.0
180-185	8.4
185-+	7.2

The limoene was identified by conversion into the tetrabromide.

THE CHARACTER OF THE COMPOUND FORMED BY THE ADDITION OF AMMONIA TO ETHYL-PHOSPHO-PLATINO CHLORIDE, by Chas. H. Herty and R. O. E. Davis. Jour. Am. Chem. Soc., vol. 30, p. 1084. July 1908.

Efforts to prepare Rosenheim's Salt $\left\{ Pt \begin{matrix} (NH_3)_2 \\ P(OC_2H_5)_3 \end{matrix} \right\}_2 Cl_4$ failed. On each attempt, following closely Rosenheim's directions, the salt $\left\{ Pt \begin{matrix} Cl \\ (NH_3)_2 \\ P(OC_2H_5)_3 \end{matrix} \right\} Cl$ was obtained. Only half of the chlorine in this compound can be precipitated by silver nitrate. Determinations of its molecular conductivity show close agreement with analagous di-ionic complex ammonia compounds studied by Werner, Miolati and Herty. The character of the compound agrees fully with the co-ordination hypothesis of Werner.

CORROSION OF IRON, by R. O. E. Davis. Ch. Eng., vol. 5, p. 174. 1908.

The corrosion of iron in explained by different workers in several different ways, but the main discussion is whether it is oxygen or carbon dioxide that is essential to rusting. Experiments were devised to determine this point, from which the conclusion is drawn that corrosion of iron takes place with water and oxygen but not with water and carbon dioxide. The presence of carbon dioxide may accelerate the reaction but is not essential to it.

THE OPTICAL ROTATION OF SPIRITS OF TURPENTINE, by Chas. H. Herty. Jour. Am Chem. Soc., vol. 30, p. 863. May 1908.

The results of this investigation were obtained from oleo-resins from individual trees in Florida of Pinus Palustris and Pinus Heter-

rophylla. The collections of the oleo-resins from which the volatile oils were distilled were made at regular intervals throughout a complete season, March to November. A number of trees of eacb species were used.

The optical rotation of the severel volatile oils obtained on distillation showed a marked variation. Those from Pinus Palustris were generally dextrorotatory, varying however from +1° 23' to +18° 18' (100 mm. tube). One specimen showed a levorotation of —7° 26'. The oils from Pinus Heterophylla were levorotatory, with one exception +0° 15', varying from —7° 31' to —29° 26'.

While these wide variations were noticed in the specimens from the individual trees, there was but slight variation in the specimens from the same tree throughout the season.

114

JOURNAL

OF THE

Elisha Mitchell Scientific Society

DECEMBER, 1908

VOL. XXIV NO. 4

THE AMANITAS OF NORTH CAROLINA

BY H. C. BEARDSLEE

The Amanitas are among the most conspicuous and interesting of our fleshy fungi and for that reason most frequently serve as the starting point for the beginner. In the following paper the attempt has been made to furnish a key and synopsis of the genus which will be serviceable to students of this state. All the species which are listed, with two exceptions have been found near Asheville and will be found generally distributed through this and the surrounding states.

The names used are in the main those in common use. The few changes which have been made, have been determined upon only after carefully comparing our plants with European specimens and after submitting good specimens and life sized photographs to European authorities. Bresadola, Boudier, and Carleton Rea have given much assistance in this work and have placed the author under great obligations.

The genus Amanita may be distinguished among the white spored species by the volva which surrounds the entire plant in its younger state. In the mature plant this is often largely obliter-

ated, but its remains will usually be seen on the pileus or at the base of the stipe, according to the nature of its development. In some cases the valva is a loose membranous sack, which splits as the pileus develops, and is left as a loose cup at the base of the stipe. In other cases the volva breaks at the margin of the pileus leaving a part adherent to the pileus in the form of irregularwarts, while the basal portion remains adherent to the base of the stipe, either in the form of a sheath with an even margin where it has been ruptured, or in the form of scales.

Species, then, with white spores, a distinct cup at the base of the stipe, or the pileus adorned with superficial warts may be looked for in this genus. The Volvarias wich are rather rare have the same loose cup at the base of the stipe, but will be at once distinguished by the red spore print which will be obtained by placing a cap on white paper,

KEY TO THE GENERA AND SPECIES

Stipe furnished with an annulus.	Amanita.
Stipe without an annulus.	Amanitopsis.

Amanita.

Volva forming a loose membranous cup at the base of the stipe		1.
Volva forming a distinct marginate sheath adnate to the stipe		3.
Volva not as above.		4.
1. Gills yellow.	A. caesarea.	
1. Gills white, margin of pileus striate.	A. spreta.	
1. Gills white, margin ef pileus even.		2.
2. Annulus remaining white.	A. phalloides.	
2. Annulus becoming sooty black.	A. porphyria.	
3. Pileus yellow.	A. mappa.	
3. Pileus white.	A. cothurnata.	
3. Pileus gray or brownish gray.	A. pantherina.	
4. Pileus striate on the margin, spores elliptical.	A. muscaria and A. russuloides.	
4. Pileus striate on the margin, spores subglobose.	A. frostiana.	
5. Flesh with red stains when wounded.	A. rubescens.	
5. Not as above.		6.
6. Pileus adorned with erect pointed warts.	A. echinocephala.	

6. Pileus adorned with thin, adnate, polygonal warts.
A. solitaria.
6. Pileus adorned with thick, large polygonal warts.
A. strobiliformis.

Amanitopsis.

Volva persisting as a membranous cup.	1.
Volva separating into warty scales on the pileus.	2.
Volva pulverent.	A. farinosa.
1. Pileus sulcate striate on the margin.	A. vaginata.
1. Pileus even on the margin.	A. agglutinata.
2. Pileus red.	A. muscaria coccinea.
2. Stipe distinctly bulbous.	A. russuloides.
2. Not as above.	A. strangulata.

AMANITA CAESAREA SCOP.

Pileus 4 to 10 inches broad, smooth, varying from bright scarlet to orange or dingy yellow, distinctly striate on the margin; gills yellow, free; stipe firm, stuffed, usually yellow and floccuiose, with a large, persistent annulus. Volva large thick loose, persistent, white. Spores elliptical, 10 to 12 by 5 to 6 mc.

This is easily the finest and most striking of the Amanitas. It is very abundant in Western North Carolina, but is rare farther to the north. It is highly esteemed in Europe as an edible species, but like all the Amanitas should only be used for food when it has been identified beyond all possibility of mistake. It should be remembered that several species of Amanita are highly dangerous.

AMANITA SPRETA PECK.

Pileus 2-6 inches broad, usually gray, or brownish gray, but varying to white. Smooth or nearly so, striate on the margin; gills white, free; stipe cylindrical, not bulbous, stuffed or hollow. Volva loose, free, persistent. Spores 10-12 by 7-8 mc, elliptical.

This is very abundant and also very variable. The common form at Asheville is large and robust, with the margin nearly even, and the pileus brown or dark gray. Other forms are found which are slender and occasionally almost pure white. The more slender forms are much like A. cinerea Pres. which is the European form of this species. One interesting form occurs on our dry hill-

sides which is so distinct that both Peck and Bresadola declare it a distinct species, Careful observations have lead to the conclusion that it is however merely a very distinct variety. I have figured it as A. spreta parva n. var. It may be readily known by its small size. Pileus .5 to 1 inch broad, thin and membranous, soon plane or depressed, deeply sulcate striate on the margin. Stipe slender white with a distant, almost median annulus. Spores as in the type.

AMANITA PHALLOIDES FR.

Pileus 2-5 inches broad, omooth or with a few fragments of the volva, white, yellow, or oliveaceous, often darker on the disk, margin even; gills white, free; stipe white, smooth, bulbous at the base, which is surrounded by the globose, free, membranous volva. Spores globose 9-10 mc.

Common and variable in color. The most common form is pure white and so distinct that it has been separated under the name A. verna. This may be found in our woods in profusion. It may at once be recognized by its pure white pileus, and the globose base of the stipe surrounded by the loose volva. This is the deadly Amanita. It should be remembered that in spite of its attractive appearance it is the most dangerous of our Agarics.

AMANITA PORPHYRIA A. AND S.

Pileus 2-4 inches broad, brownish gray often with a tint of purple, even or slightly striate on the margin, smooth; gills white, slightly adnexed. Stipe stuffed, then hollow, bulbous at the base; volva free; annulus persistent, becoming sooty black. Spores globose, 10-12 mc.

This species has not as yet been detected at Asheville, but is inserted in the conviciion that it will eventually be found here. It has been found by the author in Maine agreeing in every particular with specimens found in Sweden. The peculiar annulus should distinguish it. It collapses upon the stipe and forms a sooty ring which is characteristic.

AMANITA COTHURNATA ATKINSON.

Pileus 2-4 inches broad, white, viscid when moist, covered with

flat, irregular, white warts, striate or tuberculate striate on the margin; gills white, free, broadest at the margin; stipe slender, white, abruptly enlarged into a globose bulbous base. Volva adnate to the base of the stipe, upon which it forms a distinct sheath with a distinct margin. Spores elliptical, 8-10 mc.

Very abundant during the summer. We have used the American name, though with the conviction that this is only a form of A. pantherina. One of the decisive reasons for its separation from A pantherina was that the spores are globose instead of elliptical. This is certainly not true of the fresh plant, though the spores in my dried specimens show a curious habit of becoming distended, and are filled with a large globule which takes the place of the proper contents. The main difference is in the color which is a doubtful character. Typical A. panterina has a dark pileus upon which the white warts are very conspicuous. The curious sheath at the base of the stipe will at once characterize this species.

AMANITA MAPPA FR.

Pileus 2.5 anches broad, yellow or pallid, dry, with flat white or yellow scales from the fragments of the volva, even on the margin; gills white slightly adnexed; stipe stuffed then hollow, white, striate at the apex, with a globose marginate bulb. Spores globcse 8 mc.

Found in pine woods, rather rare. This is identical with the the plant which is found in Sweden. It is much like A. phalloides in some regards but has no free volva. The basal portion of the volva is adnate to the bulb and is cut squarely across forming a thick margin at the margin of the bulb.

AMANITA RUBESCENS PERS.

Pileus 2 to 5 inches broad, brown, or red brown, varying to pale or yellow, even or slightly striate on the margin, thickly covered with irregular fragments of the veil, somewhat viscid when moist; gills white, rather narrow, tapering toward the stipe; stipe white, stuffed, becoming hollow, usually bulbous at the base. Flesh of plieus and stipe becoming red when wounded. Spores elliptical 7-9 by 5-6 mc.

Very common. In mature specimens it can at once be recognized by the red stains which will be seen where insects have formed their burrows in the stipe. No trace of the volva will be seen at the base of the stipe in the mature plant.

AMANITA MUSCARIA LINN.

Pileus 3 to 6 inches broad, viscid when moist, thickly covered with the remains of the volva, which breaks up on the pileus in the form of irregular white or yellow warts, varying from bright orange to yellow or pallid, striate on the margin; gills white; stipe white or yellowish, bulbous at the base which is at first covered with scales from the volva. Spores 8-10 by 6-8 mc.

Probably the best known of the Amanitas. The bright orange forms are very beautiful, but the more dingy forms are with us, the most common. It should be carefully distinguished from A. caesarea especially by those who are interested in the Caesars mushroom for food, as it is a dangerous species. The two species may be also identical in color. In other respects they are widely different. A. caesarea has a loose cup shaped volva at the base of the stipe, yellow gills, and a smooth pileus. A. muscaria has no cup shaped volva, white gills, and a warty pileus. No difficulty should be experienced in distinguishing the two species but all doubtful apecimens should be rejected as being possibly the most dangerous A. muscaria.

AMANITA MUSCARIA COCCINEA BEARDSLEE.

Pileus bright scarlet, viscid, striate on the margin, thickly covered with yellow warts. Gills yellow, yellow pulverent on the margin; annulus lacking. This is one of our most striking forms and is so constant that it deserves recognition, especially as it seems to be quite abundant. It may prove to be not distinct from A. gemmata Fr. and A. nitido guttata Paul. though it does not well correspond with the discriptions.

AMANITA ECHINOCEPHALA VITT.

Pileus 3-8 inches broad, pure white to dull olive green, thickly covered with erect pointed scales; gills from pure white or cream to sordid olivaceous, free; stipe solid, colored like the pileus,

mealy or clothed, especially below, with pointed scales, enlarged at the base into a bulb from which a long root like projection is given off. Strong odor of chlorine in old plants. Spores elliptical, 10-12 mc. long.

AMANITA SOLITARIA AULL.

Pileus white or slightly gray, convex, even on the margin, covered wieh thin adnate polygonal warts: gills white, free: stipe solid white, flocculose, somewhat bulbous at the base, bulbs pointed. Spores 10-12 by 7-9 mc. Odor as in the preceding. In woods, less abundant than the preceding species.

AMANITA STOBILIFORMIS PAUL.

Pileus large and firm 3 to 8 inches broad, white or light gray, covered with thick brown polygonal warts, even on the margin; gills white; stipe thick, solid, farinose or scaley, enlarged below into a bulb which is often marginate. Spores 10 to 12 mc elliptical.

I have given here the description of these three species in order to facilitate the study of the group to which they belong. It is necessary to add that the status of this group is more than doubtful, and that there is no agreement among the best authorities in regard to it. The truth in regard to the group seems to be this. It is rather rare in the north. Peck says for example that it is of little consequence to determine whether it is or is not edible on account of its rarity. In the south it is abundant and can be gathered by the bushel. It seems certain that only one who has observed it in comparative rarity should feel sure of the distinctions which are drawn. My observations which are recorded in a large series of photographs are that none of the "characters" are constant enough to be of much value. The shape of the warts and their nature seems to depend largely upon the conditions of development and, in what is clearly the same species, may vary from a thin mealey covering to hard polygonal warts. The shape of the bulb is just as uncertain. In the same species it may be entirely lacking or highly developed, marginate or immarginate, and smooth or scaley. While the dimensions of the spores vary I have been unable to base any sep-

aration on this character. The most striking forms which occur in North Carolina are a form which is dull olive green throughout and gives dark olive spore prints (apparently A. umbella of Cuelet and Bataille's monograph) and the huge attractive form which has been known as Lepiota vittadinii Moret. Upwards of thirty "species" have been described in this group, part attributed to Lepiota and part to Amanita. Most of these are certainly of no value. It is my present opinion that they will all eventually be reduced to synonyms. It is hoped that those who are interested in the subject may secure specimens and photograps of members of the group which are found in their vicinity. It is only by the study of ample material that the matter can be cleared up.

AMANITA RUSSULOIDES PECK.

Pileus 2 to 4 inches broad, pale yellow, viscid when moist, covered at first with white irregular warts, tuberculate, striate on the margin; gills white, free; stipe stuffed, smooth, bulbous. Spores 10 to 11 by 7 to 8 mc. Very abundant in the Asheville region. It is known in Europe as A. junquillea Quel. Amanita vernalis Gilet and A. amici are doubtless but forms of the same species. It is probable also that A. adnata Smith is to be referred here. The form found at Asheville has either no annulus, as is the case with the form figured by Smith or at the most a very rudimentary one. The species is doubtless not rare in our State and will be easily recognized. The pale yellow or straw colored pileus with its striate margin and the rounded bulb at the base of the stipe are characteristic. Specimens from Boudier have been carefully compared with our own material and there can be no doubt of the identity of the two.

AMANITA FROSTIANA PECK.

Pileus 1-2 inches broad, bright yellow or orange, warty from the remains of the volva, even or slightly striate on the margin; gills white, stipe white or yellow, bulbous, spores 8-10 mc, broadly ellipticalor globose. Growing in woods. In appearance this is a small A. muscaria, but the spores are different. It will doubtless be found generally through the the state.

AMANITOPSIS.

This genus differs from Amanita in the absence of an annulus. The division is rather artificial and the fact that some species are found either with or without an annulus makes it of questionable value.

AMANITOPSIS VAGINATA BULL.

Pileus ovate, becoming expanded and plane or depressed, pallid, gray, tan or brown in color, naked or with a few flat fragments of the veil, deeply sulcate, striate on the margin; gills white, free; stipe slender, tapering upward, flocculose; volva membranous, persistent, lax. Spores globose 7 to 10 mc. One of our most abundant and variable species. The loose, cup shaped volva at the base of the stipe, lack of an annulus, and striate margin readily distinguish it.

AMANITOPSIS AGGLUTINATA B. & C.

Pileus firm, convex, even or only striate on the margin, white, slightly colored on the disk and somewhat flocculose scaley; gills white, broad, rounded; stipe not enlarged at the base, equal or tapering upward, stuffed flocculose; volva firm, free, forming a persistent, membranous cup at the base of the stipe. Spores elliptical 11-14 by 5-7 mc.

This is A. volvata Peck and is shown under that name in this country. In Europe it is considered by Bresadola to be the real A. baccata of Fries. Boudier finds it and refers it to A. coccola. Specimens from him are identical with our plant and his figure(Bulletin of the French Mycological Society, Vol. 18, Page 253] represents it perfectly. The description given by Berkeley is however unmistakable and is substantiated by specimens. It seems best to use the first authentic name since A. baccata Fr. must always be an uncertainty. Fries' figure of A. baccata does not seem to represent our plant. A. barlae Quel. is probably another synonym.

AMANITOPSIS STRANGULATA FR.

Pileus 1-4 inches broad, campanulate, becoming expanded and plane or depressed, brown or gray-brown, deeply striate on the

margin, warty, viscid when moist: stipe tapering upward, slightly enlarged at the base, white. Gills not crowded, white, free; volva firm in texture, breaking up into broad felty scales on the pileus and forming a more or less perfect ring which projects like a false annulus from the base of the stipe. Spores globosed 10-12 mc. This is not rare in the mountains af West Virginia and I have included it here although it has not been reported as yet from North Carolina. It comes close to A. vaginata, but seems sufficiently distinct. The curious false annulus is its distinguishing mark.

AMANITOPSIS FARINOSA SCHW.

Pileus 1-2 inches broad, gray or brownish gray, mealy with gray particles which are thickest at the disk, deeply striate on the margin; gills white, free; stipe slender, pallid or gray, bulbous at the base. Spores elliptical or subglobose 6-7 mc long. In open woods along paths. Common.

This dainty species is common in western North Carolina, but is rare farther to the north and is entirely unknown in Europe. The volva is represented by a gray farinose covering which at first covers the entire plant. It is a very distinct and attractive species.

AMANITA SPISSA should be found in our state and it is hoped that collectors will watch for it. It is much like some forms of A. rubescens but the warts on the pileus are gray and the flesh unchangeable. I have observed it in Maine but not at Asheville.

ASHEVILLE, N. C.

INVESTIGATIONS OF THE N. C. GEOLOGICAL AND ECONOMIC SURVEY RELATING TO FORESTRY PROBLEMS ALONG THE NORTH CAROLINA BANKS

BY JOSEPH HYDE PRATT, STATE GEOLOGIST

Problems of considerable interest have recently come up regarding the preservation of the small areas of forests that still remain on a few sections of the Banks along the North Carolina coast and of the reforestation of certain other sections. Conditions along the banks have been studied and, although the investigations have shown that over certain areas it will be impractical to attempt any reforestation or to try and check the progress of the dunes, yet there are certain other areas that should be protected and reforested. The greatest enemy of the areas of forests now existing on the Banks are the dunes and one of the greatest difficulties in the way of checking the progress of the dunes is the cattle, sheep, and hogs that roam over these Banks, devouring the grass, roots, tree sprouts, etc. The survey has been assisted in its work of collecting data regarding the conditions existing along the Banks by Professor Collier Cobb of the University of North Carolina, Mr. I. F. Lewis of Johns Hopkins University, and the U. S. Forest Service. The principal investigation has been on Shackleford Banks, extending from Cape Lookout southwestward about eight miles to Beaufort Inlet and from Cape Hatteras to Hatteras Inlet, a distance of about twelve miles.

Shackleford Bank extends from Cape Lookout southwestward about eight miles to Beaufort Inlet, and is from a half to three-quarters of a mile broad. The whole Bank was, within the memory of the older inhabitants, heavily wooded over iis entire area. Owing, however, to cutting of the timber for firewood and lumber,

the sand of the beach began to drift in on the forest somewhere near 1840. At this time the beach was higher than the forest on the sound side. The beach is described by Mr. Torrey Moore, an inhabitant of the Bank since 1828, as "flattening out on the woods," and so killing the trees. At the present date the eastern end of the Bank is completely "sanded over." The original forest is represented only by several clumps or "islands" of live-oak, which happened to be hardy enough to withstand the drifting sand. Near the western end of the Bank, about two miles of this forest land still remains, though it is rapidly being encroached upon by the advancing sand. Along the seaward side of this strip the beach, originally narrow, has broadened to a quarter of a mile or more, destroying the forest as the sand moved toward the sound. The sand is encroaching on the forest with greater rapidity as the increased breadth of the beach gives more surface for the wind to take up the dry particles and blow them over on the forest.

The forest here is made up chiefly of live-oak and red cedar, with the red mulberry, holly, water beech (Carpinus), and red bay (Persea) occurring commonly. The trees are not large, but are densely massed, and serve to prevent the winter storms from sweeping over the Bank. Cutting of timber was once a common practice but is no longer so, for the reason that the islanders realize that their only protection from storms lies in the forests themselves. The trees are still sometimes used for firewood by the natives.

The inhabitants of the island live on the side of the Bank near the sound, and make their living partly by fishing and partly by gardening. The soil is a deep and mellow loam, suitable for most vegetables grown in this country. The principal plant now under cultivation are figs, tomatoes, sweet and Irish potatoes, cabbage, turnips, beans, peas, watermelons and cantaloups, If the drifting sand is allowed to advance much farther toward the sound, these gardens must be abandoned and the living of the inhabitant must become very precarious.

In the woods on the western end of Shackleford are a considerable number of ponies, cattle, sheep and goats. Sheriff Hancock of Carteret County estimates the numbers from Cape Lookout west

as follows: Three hundred ponies, 500 sheep, 250 cattle, 300 goats. These animals are very destructive, and are rapidly destroying all grass, shrubs, and tree sprouts on the Banks. Commercially they are of little value and a law compelling the people to keep them up would in the end work no hardship on the citizens of the Banks.

A more important, though less immediate, reason for checking the sand drift lies in its effect on the channels and fisheries of the sounds. Where the once wooded Bank has become a sandy desert, the sand blown by the wind has filled in or is filling in the channel of Core Sound. Wherever the woods are still in existence, the deep water extends up to the Bank, but where the woods have been exterminated, the channel near the Bank haf been filled up, being now only one or two feet deep at low water. This in itself is not of great importance for navigation so long as other channels near the mainland can be kept open, However, as the sand drifts in, these will gradually become shallower until, probably within the course of a few decades, the waterway between Bogue and Pamlico sounds will become closed. The effeet of a filling in of the channels would be disastrous to the fishing industry at this point. The enormous stream of mullet and other fish now coming through Core Sound from Pamlico would be diverted to some other outlet, and fishing would cease to be a means of existence to the people of the region.

As an example of the effect on the people of the drifting sand, attention is called to Diamond City, a fishing viliage on the sound side of Shackleford Bank not far from Cape Lookout. When the forest covered this part of the Bank the villagers were prosperous, being sure of a good catch of fish and having productive gardens under cultivation. As the sand came over from the beach, the gardens were first destroyed, then the channels began filling in and the catch of fish fell off. Finally, as the sand spread out more and more, the winter storms began to sweep the Bank more and more completely, until, about 1903, conditions became such that the settlement was broken up, and the inhabitants, about four hundred in all, were compelled to move over to Harker's Island, near the mainland. Now Diamond City is visited only in the fall,

when fishermen take up temporary quarters during part of the fishing season.

To the north of Cape Lookout, the more important forest areas are on Hatteras Island, between the inlet and the cape, one just to the west of the Cape consisting largely of loblolly pine, and another near Hatteras village, composed largely of red cedar, pine and live oak. To the southwest of the inlet there are small scattered areas, containing a good many olive trees. These latter trees make especially good binders in checking the advance of the sand dunes inasmuch as they are able to sprout from their branches, after the main part of the tree has been covered by the sand.

There is one element of the situation which, so far as is known, is different from the conditions where sandbinding work has been instituted, as, for instance, Cape Cod. The winds which cause the sands to move are from the south, blowing pretty constantly during the spring and summer, or growing season. The stronger northeast winds of winter have little effect on the sand. What effect they have consists in blowing the sand back towards the ocean. They are less effective as sand movers than the south winds of summer, partly because they blow less constantly and partly because their force is greatest when the sand is wet from winter rains and not easily to be moved. At any rate, the sand is moving north, carried so chiefly in the summer months, whereas at other points where conditions have been studied, it moves south and west, being blown by winter winds. This condition, which probably obtains along the South Atlantic and Gulf coast, causes the problem to to be presented in a slightly different aspect from that usually considered, and serves to emphasize the desirability of experimental work at this point.

A special report was made for the N. C. Geological and Economic Survey, by Mr. Jay F. Bond of the U. S. Forest Service on the practicability of forest protection on the Banks and how to accomplish it. Mr. Bond's report is as follows:

EXAMINATION OF THE NORTH CAROLINA BANKS

Introduction

The following report is the result of a brief examination of the

banks off the North Carolina coast between Cape Hatteras and the wooded area about six miles west of Beaufort Inlet. This investigation was undertaken by the Forest Service at the request of the State Geologist of North Carolina and was intended only to determine, in a general way, the damage being done by drifting sands on the area examined. If considered necessary, methods of protection against further damage were to be recommended.

The portion of the banks covered by this report is typical of the entire strip and within this area are the only places where active protective measures seem to be required at the present time. A detailed plan for the treatment of these lands is included in this report.

Damage by Shifting Sands

There is abundant evidence, throughout the area examined, of marked changes within a comparatively recent time. Within the recollection of many of the residents, practically the entire banks were forest covered. At present, however, the forests occur only at two points. Immediately west of Cape Hatteras are approximately 2,500 acres covered principally with loblolly pine. Recent estimates of the amount of pine in this stand approximate 20,000,000 feet board measure. Although this figure seems excessive, there is undoubtedly a considerable amount of valuable timber in forest. The trees are of medium size and the lumber of relatively low value, but the accessibility of the stand and the great market for even the poorer grades will make the exploitation of this timber profitable. These lands are held by private owners and the stumpage is controlled by a company which holds an option at $.50 per thousand feet, B, M. This option expires January 1, 1910.

Poor business management has caused a suspension of logging operations, but it is practically certain that lumbering will be resumed in the near future and that a considerable portion of the forest will be removed before the expiration of the option, since it could be renewed only at a much higher rate.

Near the western end of Shackleford Banks are a few hundred acres of forest composed almost entirely of red juniper. This is being exploited in a small way for posts.

The entire area between these points is barren and unproductive. Only at the villages of Hatteras and Ocracoke where the residents maintain small gardens is there any attempt to utilize the land in any way except for the pasturage of a small number of stock. Sand more or less fixed in the form of dome-shaped dunes extends from the ocean to the sounds. The damage here is complete and the improvement of the area as a whole is practically impossible.

There are two localities on the area under discussion where protective measures would prove a decided benefit. At the southeastern and southern part of the woodland near Cape Hatteras the blowing sand is rapidly encroaching upon and destroying the forest while at Beaufort Inlet the surface sand is being blown into Core Sound and, through the destruction of the beach, the width of the inlet is perceptibly increasing. The problem of arresting the damage at these two points is discussed in detail below.

Cape Hatteras Forest

Along the entire southern and western edges of the forest west of Cape Hatteras a considerable area of woodland is being buried and destroyed by blowing sand. As stated above, this timber has a distinct value and, in addition to its value for lumber, the occurrence of the forest makes this locality by far the most desirable residence section of the banks. It is simply a question of a rather limited time, however, when the encroachment of shifting sands, together with destructive logging, will complete the permanent denudation of the area.

The greatest difficulty to be encountered in the treatment of these lands is the fact that they are private property and therefore can scarcely be controlled by legislative action. Apparently nothing can be done, except in an advisory way, to regulate the exploitation of these woods. Fortunately, however, the logging operations were begun at the sound side of the forest remote from the area being encroached upon by the sand and hence the cutover area will have an opportunity to reforest naturally before the removal of the timber immediately in the lea of the approaching sand dunes. The large proportion of loblolly pine in the stand makes reproduction certain with a minimum of protection. It is

certain, however, that by far the greatest factor in the destruction of the original stand has been careless lumbering.

The destruction resulting from logging has been made permanent by unrestricted grazing, Cattle, sheep, goats and hogs have free range and the damage from these sources cannot be overestimated. Hogs are the greatest menace and a single hog, practically valueless, will root out large areas of sandbinding grasses along the beech. Cattle and sheep complete the destruction by eating the roots of the uprooted grass. The sand thus liberated is carried away by the wind and a "blow-out" results. This blow-out constantly enlarges until the damage becomes general and large areas are affected.

Even if grazing were an important industry on the islands, free range of stock would be fatal to the industry itself as well as to the general productiveness of the lands. The reverse is the fact, however, since competent observers place the total value of all stock between Cape Hatteras and Hatteras Inlet at no more than $1000. The cattle, sheep and horses are in-bred and of minimum value while the hogs are practically worthless since the meat is unfit for consumption, owing to the carrion fish upon which they feed.

It is strongly recommended, therefore, that the Legislature enact suitable laws providing for the fencing of all stock upon this portion of the Banks. This will work no real hardship upon stock owners and, moreover, is an economic necessity if the industry be made profitable. Without such legal protection, all measures for the control of shifting sand such as are described below will be useless. In addition, natural reproduction on the cut-over forest areas cannot be satisfactory since, under present conditions, live oak reproduction, which would otherwise be abundaut, is missing and even pine reproduction is very seriously damaged.

The sand dune area which is encroaching upon the forest lies to the south and east of the woodland. Beginning at a point two miles east of Creed's Hill Life Saving Station, it extends westward four and one-half miles and beyond the wooded area where the sand extends entirely across the banks to the sound. A description of this area and certain recommendations appear below.

Cape Hatteras Sand Dune Area

The moving sand of the dune area between the forest and the ocean has already covered up and destroyed the growth for about one-half mile inland. At the western end of the dune the sand gradually slopes into a low marshy area which extends to Durant's Life Saving Station where a small body of live oak occurs. To the south of this woodland is a long, narrow sand dune and to the west a low wash-flat extends to Hatteras Inlet where there are a few mound-like dunes near the beach.

It is only the dunes immediately south and west of the Cape Hatteras forest which are discussed below, since the dunes further to the west can do practically no damage. Over this entire area the sand is constantly moving in a northeast direction. The surface is practically bare of vegetation and such growth as does spring up from time to time is promptly destroyed by stock.

The direction of the movement of the dunes is undoubtedly influenced by the forest growth which shelters the area from the northerly winds. From the south the winds have uninterrupted sweep and, in consequence, the sand is carried by these winds in a northerly direction. The prevailing winds in the different seasons also have a greater or less influence on the direction in which the sand is carried. During the summer the sand becomes very dry and in this condition is easily carried by the winds which are southerly at this season. In the winter, however, the moist condition of the sand prevents it from being easily carried by the northern winds which prevail. The result is that even where the winds have full sweep in both directions the general movement of the dunes is toward the north.

At the northern end of the sands the dunes terminate abruptly at the edge of the woods. Here there is a high dune rising gradually to a height of about 25 feet. To the leeward the slope of the dune is fully 35°, which seems to be as steep as sand will remain at rest.

The rate at which this dune is advancing inland could not be determined the short time available. It is very evident, however, that the advance is relatively rapid, since there are numerous liv-

ing tops of trees protruding above the sand considerably to the windward of the crest of the leeward dune.

To control and fix these sands will require most careful treatment and an expense entirely disproportionate to the value of the reclaimed land and of the forest lands in the lea. So long as the present conditions in respect to laws and the ownership of the greater part of the area exists protective measures are impossible. In addition to the enactmen of stock laws as recommended above, it is recommended that the state acquire by purchase a strip of the forest land in the lea of the dunes not less than 500 and preferably 1,00 feet wide and extending along the entire area so far as the forest occurs. When this has been done the active measures looking to the control of the sands may be put into effect.

The Fixation of the Sands

The permanent reclamation of the sand waste depends upon two things: (1) Since the source of supply of the sand is inexhaustible, a barrier must be provided near the beach to prevent new supplies of sand which aré brought up by the surf from being blown inland. (2) The loose moving sand in the lee of this proposed barrier must be permanently fixed by growing forests.

The success of all work relative to the satisfactory growth of the trees and consequent binding of the sand depends upon the barrier and past experience has established that this barrier is most satisfactory, if it consist of a littoral dune of proper height built up by sand which is arrested by means of mechanical obstructions and held in place by suitable sand-binding grasses. It should be built up parallel to the shore line and not nearer than 100 feet to high water mark.

When the work of fixation is complete, the entire area with the exception of the strip between the barrier dune and the shore line will be covered by a forest. The strip to the windward of the barrier must be held in place by the planting of grass. When the forest has been established, it should be cared for according to usual forest practice.

It will be impossible to establish a forest directly upon the drifting sand either by sowing the seed or by setting out young trees, since the blowing sand either uncovers the seed or buries it too

deeply, while in the case of planted trees, the sand cuts the leaves and bark or buries the plants. It will therefore be necessary to hold the sand in place by some mechanical covering until the trees have developed and formed a natural cover.

The work of fixation is thus divided into two stages: (1) Preliminary, holding the sand in place. (2) Permanent, establishing a forest. Upon the coast strip the work never proceeds beyond the first stage and the maintenance of a grass cover will require constant care.

The Coast Strip and the Barrier Dune.—The coast strip and the barrier dune should be handled in such a way that the surface of the strip may not jeopardize the stability of the dune. It is obvious that the first work is the proper formation of the dune. This is done by rapidly accumulating blowing sand so as to form a long ridge. For this purpose, palisade fences arranged in a double row 6 feet apart are used. Each fence should be made of inch boards 6 inches wide and 5 feet long, driven about two feet into the sand. The tops of the fences should be of equal height and the palings should be four inches apart. Such an arrangement of fences allows the wind to pass through, but reduces its velocity and hence sand is deposited within and on both sides.

As the sand accumulates to the tops of the fences, the palings should be raised and, when the dune has reached a height of 30 feet, sea oats (*Uniola Paniculata*) should be planted 3 feet apart alternating in rows three feet apart, parallel to the crest of the dune. The grass should be planted on both sides of the dune and gradurlly extended toward the windward until the dune attains a fairly permanent form with a gradual slope toward the windward, while on the leeward side the slope will be approximately 30°. The successive steps in the formation of the barrier dune is shown in the series of diagrams accompanying the report (Plate I).

The barrier dune, when completed, will protect the area in the lee but will require constant care tc keep it in proper condition. Every precaution should be taken to prevent a break in the dune and, if such occurs, it must be repaired immediately, since the wind will constantly enlarge the opening. A break may be repaired by the simple expedient of piling brush on the surface of

the blowout and, when the sand has filled in to its former level, by replanting grass as before. The main care should be to maintain a good grass cover over the dune and the coast strip. When the grass becomes thin in one place, plants should be taken from areas where it is thicker than necessary and replanted where required.

Forestation.—The area in the lea of the littoral dune must be planted in forest trees to accomplish permanent fixation. Local conditions and geographical position of the area to be planted are such that proven methods developed in extensive work of this character in Europe may be adapted to this project.

It has been established that the most certain method of securing a forest cover on waste sands is by direct sowing of the seed, provided that suitable species are available for use in the locality and also that the sand be temporarily fixed until the young trees are well established. Upon the formation of the barrier dune the sands in the lee will be comparatively free from the action of the wind, since the dune will protect the area from the southerly wind, while the forest will serve as a windward to the north.

Loblolly pine, a rapid growing species which produces valuable timber, grows throughout the banks. Although, owing to the exposed situation, the qualiiy of timber produced cannot equal that of the forests of the mainland, this tree is by far the most desirable commercial species on the banks.

The proper method of sowing the seed can be determined only by experiment. Two methods are suggested, the second to be used only when it has been clearly demonstrated that the first is not feasable. (1) Sowing the seed directly on the surface. (2) Sowing the seed after the sand has been temporarily fixed by a light covering of brush.

At the western end of the shore dune, on a strip 500 feet wide and extending from the dune to the forest, loblolly pine should be sown at the rate of 12 pounds per acre. The seed should be sown directly on the surface of the sand without any preparation of the site. Although there is good reason to count upon favourable results, there are several possible objections to this method. Large quantities of the seed are almost certain to be destroyed by

birds and to guard against this the seed should ke coated with red lead before being sown. Again, wind will blow away some of the seed and in other cases will cover the seed too deeply with sand. It is certain that the action of the wind will be greatly reduced by the littoral dune and the forest, but just how efficient this shelter will be can be determined only by actual experiment.

It is obvious that if the sweep of the wind over the area in the lee of the dune is not reduced to a minimum, the success of planting by direct sowing without previous preparation of the site will be impossible. In such a case the surface of the area to be planted must be covered with a light covering of brush, laid in rows parallel to the barrier dune. Seed should then be sown at the same rate as above among the brush.

Such a method, although more expensive than the first plan, will insure success. The brush should be allowed to remain until the young trees are established and the year following the sowing it should be removed in order not to interfere with the growth of the seedlings.

Brush can be obtained from the nearby forest. Myrtle, red bay, yaupon, or any similar material may be used. Brush cut from the tops and limbs of conifers after lumbering will serve admirably. Such material may be obtaided from recently cut-over areas in the forest.

The forest immediately in the lee of the sands, the purchase of which has been recommended above, should be carefully conserved. Absolutely no cutting should be permitted until the dune forest is firmly established.

The expense of fixing the sands can be only approximated. There was no opportunity in the limited time available to determine the rapidity at which the barrier dune would accumulate. It is obvious therefore that the cost of the dune cannot be determined, since it will vary directly with the the length of time which will elapse before it assumes permanent form. The cost of forestation can, however, be approximated, and will vary from \$25 tn \$40 per acre, depending upon the method. Seed of the loblolly pine are quoted in the market at \$2 per pound but could undoubtedly be secured by contract at a much lower figure.

Material for the palisade needed in the building up of the barrier dune represents a first cost of $900 at present prices and labour for its construction will add at least $500. The cost of maintenance cannot be predicted.

Grass planting on the coast strip and the littoral dune will be expensive and at least $500 must be allowed for this work exclusive of maintenance.

The entire cost of the work of fixation, exclusive of any expense necessary in the acquisition of the lands, will reach at least $40,000.

Advisability of Project.—This report does not aim to outline a policy. It merely suggests a definite plan by which the areas under discussion can be protected and leaves the advisability of the action to the proper authorities.

The work of fixing the sands will serve to accomplish the perpetuity of the only forest remaining on the banks above Beaufort Inlet. If prompt measures, such as outlined above, are not taken, the destruction of the forest is certain. The lands will become a sand waste similar to the larger part of the area of the banks. The cost of the work, however, is large and it is doubted if the value of the property to be protected will equal the cost.

Aside from the intrinsic value of the property, it must be considered that this area supports a considerable population which will be seriously affected should the land become waste. These people are entitled to protection by the State and, although relief could be secured by temporary measures involving less immediate expense,, the method of treatment recommended necessitates the lowest coast consistent with permanent protection.

If, however. the project is undertaken, it is strongly advised that the work of carrying out the details of the general plan advised be entrusted to a competent official and be made a part of his duties.

The Beaufort Inlet Project

The Department of War maintains a series of sand fences on either side of Beaufort Inlet at the entrance to the harbor. These fences are to hold the sand as it is brought to the beach in order to build up the beach and prevent the inlet from increasing in

width. The effect of the blowing sand which might be deposited in the channel is not considered, since the currents will serve to keep the channel clear.

Since the Department of War has made provision for the continuance of this protective work, a further discussion is not essential.

These investigations regarding the preservation of the forests on the Banks of North Cirolina will be continued by Mr. W. W. Ashe, Forester of the Survey, and he will also have supervision of any work that the Survey may undertake to actually protect and perpetuate the forests.

STREPTOCOCCUS INFECTIONS OF THE TONSILS, THEIR DIAGNOSIS AND RELATIONSHIP TO ACUTE ARTICULAR RHEUMATISM.*

BY WM. DEB. MACNIDER.

Perhaps it may seem a rather late day to resurrect such an old and well studied subject as throat infections and their diagnosis. The subject has recently aroused much interest in me from having to deal with two small epidemics of such cases which proved to be of a non-diphtheritic nature and from the complications referable to the joints which several of these cases developed.

Within the past two years I have had the opportunity of studying fifty-eight infections of the tonsils and adjacent soft ports. With but few exceptions these infections have been in males between the ages of 16 and 30. Six were in children between 3 and 8 years of age and four cases occurred in women.

The acute inflammations of the tonsils are usually due to infections by the Staphylococcus or the Bacillus Diphtheriæ. Some organisms of the streptothrix group which are usually present in the mouth and which are non-pathogenic, may perhaps under favorable circumstances become pathogenic and should be classed among the organisms capable of causing acute infections of the throat.

These organisms may be present in pure culture, but frequently a mixed infection exists. In such cases a styphylococcus is often the organism. It is a large coccus, grows luxuriantly on the ordinary culture media add is feebly pathogenic for rabbits when they are inoculated subcutneously.

---

*Reprinted from The Charlotte Medical Journal, September, 1908.

In the ordinary cases of acute follicular tonsilitis the styphylococcus is the commonist organism found. It can be easily obtained from the white fibrinous plugs in and around the openings of the tonsilar follicles.

Of the fifty-eight cases of throat infection presented in this paper, thirty were subjected to a bacteriological examination and as the other cases which were not so examined developed within a few weeks and in the same locality as those examined, it is not illogical to conclude that they had as their cause the same organ ism.

Technique.—The bacteriological examination consisted in first making from the exudate covering the tonsils or fauces, two film preparations. One was stained with Loeffler's alkaline mythylene blue and one by Neisser's method. The last method of staining has the advantage of clearly defining the polar bodies, which are to some extent characteristic of the bacillus diphtheriæ.

Secondly with the aid of a cotton swab three blood serum tubes were inoculated from the exudate. These were incubated from twelve to twenty hours and from the colonies which formed film preparations were made and stained by the above methods.

The result of these examinations showed constantly present both in the films made from the throat and from the colonies, an organism having the characteristic chain grouping of streptococcus. Associated with this organism was a diphlococcus of rather large diameters which did not grow well on the ordinary media.

In no instance were there organisms found which at all resembled the bacillus of diphtheria. In the films made from the throat, bacilli were often present which differed from the diphtheria bacilli in that their protoplasm stained uniformly, there was no "barred" appearance, no polar bodies, the organisms were not curved or clubbed but were straight bacilli with rounded ends.

Symptoms.—The symptoms manifested in these cases were those of an acute infection. The onset was sudden with a chill or chilly sensation followed by headache, rather severe backache, a rapid rise of temperature to 103-104 deg. F., a large hightensioned pulse, which compared with the degree of fever was slow, usually about 90-100 per minute.

The tonsils in the majority of cases were only slightly enlarged. The lymphatic glands of the neck were enlarged but this change was not pronounced. The inflammatory reaction of the tonsils consisted in the formation of a grayish white membrane which covered their surface, usually involved both tonsils, and in four cases extended up the anterior pillars of the fauces. The membrane was tough, was removed with difficulty, and after its removal in many instances left behind a raw bleeding surface. In only ten of the fifty-eight cases, was the membranous deposit limited around the follicular openings.

So far as the appearance of the throat was concerned, these cases would have been diagnosed as diphtheritic infections. Such a diagnosis was made in the first four on a purely clinical basis. Their failure to respond to antitoxin treatment led to a bacteriological examination with the demonstration of a streptococcus infection.

A series of such cases, twenty-four in number, have been reported by Prudden of New York in which the streptococcus was the organism present and not the bacillus of diphtheria.

The existence of such cases renders the diagnosis of diphtheria when approached entirely from the clinical side extremely difficult, if not impossible. All cases should be subjected to a bacteriological examination before a diognosis is made.

The second point of interest which developed from the study of this series of cases was the occurrence of symptoms referable to the joints. Many of the patients complained of pain in one or more joints and in a few cases the joints were slightly swollen. Such symptoms lasted but a short time and did not return.

In four of the series the joint symptoms were prominent and persisted. For the sake of brevity a detailed history of the cases will not be given.

Case 1.—A. R. D., male, age 17. The general symptoms were those of an acute infection. The throat examination revealed a grayish membrane covering the right tonsil and sneaking up the right anterior faucal pillar. The lower half of the left tonsil was covered by a similar membrane.

The bacteriological examination demonstrated as a streptococcus infection.

Four days after the patient was first seen the right shoulder joint became swollen, red, tender and painful. The following day the left knee became involved. The joints remained swollen for about one week and gradually returned to the normal. During the time the joints were effected the temperature ranged around 103 degrees., occasionally falling to 101 degrees F., following profuse sweats. At no time was there a leucocytosis.

Case 2—L. A., male, aged 21. This case was very similar to case No 1, with the exception that the changes in the tonsil were those of a follicular tonsilitis. The exudate was more or less confined to the surface immediately around the follicles. From the exudate streptococci were isolated. A few days after the tonsilitis the right shoulder and knee joint become involved.

Case 3.—R. L. W., male age 19. When the patient was first seen he was just recovering from a severe sore throat. His chief complaint was soreness in the left shoulder joint, which he attributed to an injury. Temperature 100 degrees F., pulse 75. The following day the joint was decidedly enlarged and very painful. Five days from this the right ankle joint became swollen and painful, then the left ankle and right shoulder. Within two weeks all the joints had returned to their normal size, except the first joint affected. This joint remained slightly swollen and the movements greatly restricted.

One month from the time the patient was first seen he suddenly complained of intense pain in the left shoulder joint. Within twenty-four hours the joint had increased perceptibly in size and gave evidence of a rapid accumulation of fluid. The joint was opened, liberating a few old tarry looking clots, fresh clots and some pus. Immediately following the operation the patient became profoundly shocked from which condition he failed to rally,

Case 4.—A. H. B., male, aged 19. Mr. B. was seen early in the course of an acute tonsilar infection of streptococcus origin. The local condition had the same characteristics as previous cases. A membranous deposit over both tonsils and extending to both anterior pillars. During the early stage of the infection his temperature remained constantly elevated, ranging between 101 and

104 degrees F. At the end of the first week several points became involved, the swelling and pain presisted for several days and gradually subsided, following the subsidence of the joint changes. The joints at this stage of the infection gave no trouble but severe pain was complained of in the muscles and tendons. This disturbance continued sixteen weeks at the end of which time the patient entered on a tedious convalescence which terminated in complete recovery.

A fifth case recently seen, presented nothing in general different from the cases reported, except the development of a dry pericarditis followed by quite an extensive effusion.

The streptococcus in an organism which varies much in its morphological and biological characteristics as well as in the type of infection which it produces. In some instances it rapidly causes a septicæmia while in other cases it is content to remain a circumscribed infection producing an abcess, or at other times to extend to the adjacent structures without entering the general circulation.

The frequency with which the tonsils act as an avenue for the entrance of an infection has long been recognized. The development of a tonsilitis before or during an attack of acute articular rheumatism, first suggested the possibility of the disease being of microbic and of metabolic origin.

Taking into consideration the ease with which a local infection of the tonsil could become generalized, the frequency with which joint complications follow streptococcus infections of these structures, and lastly, the variety of changes this organism is capable of causing, it is not improbable that a modified streptococcus or or an organism clasely related to it, is the specific cause of acute articular rheumatism.

The specific cause of acute rheumatism,is at the present time, receiving much attention. There practically remains no doubt that the disease is an acute infection and that in many of the cases the tonsils are the portals of entry. The question which is at present under much discussion is whether the disease should be considered as a condition produced by one specific organism, the Diplococcus Rheumaticus of Poynton and Paine. This organ-

ism has been isolated from the synovial fluid of patients with acute rheumatism, has been cultivated on special media where it grows characteristically, and lastly an acute arthritis has been produced by various investigators by giving intravenous injections of the organism to rabbits. This diplococcus is Gram negative, the streptococcus is invariably Gram positive.

The question of the specific nature of acute rheumatism has been well summed up by Cole of the Johns Hopkins Medical School. His views are certainly conservative. They are as follows:

"I greatly fear we are not as yet in a position to make any positive statements as to the etiology of this disease. It seems to me that there are at least three possibilities. First, that acute articular rheumatism is a definite, acute, specific infectious disease, the cause of which we do not know, and that the cocci which have been isolated were secondary invaders. Second, that there is no such specific disease as acute articular rheumatism, but that the cases grouped under this term are those of a mild and moderately severe case of general streptococcus infection, in which the joints and heart are generally involved. Third, that acute articular rheumatism is due to a specific form of streptococcus, which at present we have no accurate method of distinguishing from Streptococcus Pyogenes, but which, owing to the specific character of the lesions induced in man, must possess special characteristics."

Lastly, in regard to the treatments of these cases a point of interest develops. It is well known that the salicylates have a more or less specific influence in cases of acute rheumatism. In all of these cases of streptococcus infections of the tonsils the salicylates were of great service in relieving the subjective symptoms. This relief might be produced through the general action of the salicylates on the nervous and circulatory systems, or, on the other hand, it might be explained through a germicidal action of the salicylates on the specific cause of the disease.

UNIVERSITY OF NORTH CAROLINA,
CHAPEL HILL, N. C.

THE "PINCH-EFFECT" IN UNIDIRECTIONAL ELECTRIC SPARKS.[1]

BY ANDREW H. PATTERSON.

Prof. Nipher has recently[2] described some interesting experiments on momentum effects in electric discharge, and writes as follows concerning the undirectional sparks obtained by the insertion into the circuit of strips of cloth moistened with a saline solution: "....the sparks are large and brilliant at the negative end in both positive and negative lines, and thin out towards the positive end. The negative terminals are large spheres of about 10 cm. diameter. The positive terminals are small knobs, of 1 cm. diameter. *While on the large sphere the electrons repel each other. But when they start into motion across the spark-gap, they attract each other electromagnetically.* This appears to be the reason why the spark thins out as the electrons proceed in their motion across the spark-gap. The italics are mine.

According to theory, two like charges repelling each other when at rest, begin to develop an electromagnetic attraction for each other as soon as they are put in motion in the same direction. But this attraction does not become equal to the electrostatic repulsion until the charges move with the velocity of light. This used to seem very puzzeling to me, for I reasoned as follows:—Imagine a positively charged hopper filled with steel balls, which continually dropped into two parallel inclined glass troughs. As the motion of the charged balls is constantly accelerated, the electromagnetic attraction which they exert on the charged balls

---

[1]Reprinted from Science, vol. 29, p. 731, Jan. 1, 1909.
[2]Science, vol. 28, p. 805, Dec. 4, 1908.

in the other trough grows larger and larger until the velocity is that of light, when the streams of balls in the two troughs are exerting zero fource on each other, (for their electrostatic repulsion is exactly balanced by their electromagnetic attraction), and yet they are said to be behaving like electric currents. Why, then, do parallel currents actually attract each other? No one supposes that a current in a wire travels *faster* than light. Some years ago in Cambridge I asked Prof. (now Sir) J. J. Thomson about it, and he replied that my analogy was all right, except that according to the electron theory the glass trough should have a metal covering outside, which is *positively* charged, the hopper should be *negatively* charged, and the charge on a unit's length of the trough should equal the sum of the negative charges on the balls contained in that length. Then, the analogy, while crude, would be comrlete:—the steel balls would represent electrons, and the current in the ordinary sense would flow up the trough instead of down. The charge on the covering of the trough would represent the the charges on the positive atoms in a conductor. Under these circumstances it is easy to see that attraction between the troughs would ensue as soon as the balls began to move. Prof. Nipher's explanation, therefore, would seem to be valid only on the supposition that the positive ions in the line of the disruptive discharge (which are dashing towards the negative terminal) would take the place of the metal-covered trough in my analogy, thus rendering the electromagnetic attraction of the moving electrons effective in drawing them together in a column which continually thins out towards the positive terminal. If this be true, the effect ought to be rendered more intense because of this consideration:—the analogy would then be that of the trough itself (carrying a a positive charge) *moving in the opposite direction to the motion of the steel balls*, thus making the relative velocity of the balls greater and the attraction more intense.

But there is another way of looking at it which may be more natural. The negative terminal is a large sphere 10 cm. in diameter, while the positive terminal is but 1 cm. in diameter. The lines of force are therefore strongly convergent frem the negative to the positive sphere, somewhat like the ropes from the gas bag of a

balloon to the much smaller basket beneath, and electrons sliding down these lines (along their negative direction, of course) would naturally arrange themselves in a column larger at the negative end, especially as these lines are themselves falling towards the center line of the discharge. In this case would not the phenomenon simply show the pinch effect in gaseous discharge?

UNIVERSITY OF NORTH CAROLINA,
CHAPEL HILL, N. C.

THE RECENT BALTIMORE MEETINGS OF SCIENTIFIC SOCIETIES

ZOOLOGY

Both the American Society of Zoologists and Section F (Zoology) of the American Association held meetings. Thirty three papers were read before section F and fifty nine papers before the Society of Zoologists. The meeting like all those of recent years in America gave ample evidence of the strength of the analytic tendency. Striking discoveries in morphology whether of adult forms, larvae, or embryos, or of tissues, or of cell groupings and movements during embryonic life, continue to be few. The relationships of animals (phylogenetic classification) have for the time being almost dropped from the list of subjects discussed. Keen interest is however manifested in morphological data that can be interpreted as throwing light on the physiology of development. Prominent in this connection were papers by E. B. Wilson and T. H. Morgan on sex determination and the nuclear constitution of the sperm in certain insects. These investigators produced new facts as to chromosome arrangement which lend support to the hypothesis that sex is determined in the individual germ cell by the presence of a male-producing or female-producing chromosome.

Underlying this special question of sex determination is the general question as to the nature of the whole process of differentiation during development. As bearing upon this question E. G. Conklin presented the results of an experimental study of egg organization in ascidians and mollusks. Earlier studies led him to the conclusion that the egg cytoplasm in these forms becomes differentiated into substances ("organ-forming substances") that have fixed and different potentialities, such for instance as a cytoplasmic area that necessarily develops into the notochord. Conklin employing the centrifuge alters the arrangement of sub-

stances in the egg and obtains larvae with correspondingly misplaced organs. Thus experiment confirms his earlier conclusion.

In cases like the preceding, differentiation even when interfered with is not directly affected by external factors but is clearly the result of internal agencies. A capital instance, as it would seem, of the direct influence of an external agency on the differentiating embryo was discussed by C. R. Stockard, who finds that if the fertilized eggs of the teleost *Fundulus* are treated with a trace of magnesium chloride cyclopean monsters regularly develop in considerable number. Another interesting paper dealing with vertebrate monsters and the causes of their production was presented by H. H. Wilder who sharply separates mere malformations from bilaterally symmetrical monsters which develop in an orderly fashion, as Wilder thinks, in obedience to a mechanism of control inherent in the germ.

The numerous experiments of recent years on hybridization and artificial parthenogenesis in the echinoderms have made it clear that before we can deduce with certainty the influence of the two sexes in determining the charácters of the resultant embryo and larva, we must know more about embryonic variability in the species experimented upon. D. H. Tennent has made a good step in this direction in his mapping out of the embryonic variability in the Beaufort echinoids which he has been using for experimental work.

A considerable number of papers that would collectively fall under the rubric of experimental evolution dealt with phenomena of inheritance as disclosed in the breeding of poultry, pigeons, rats, and insects. Some of the results fit in very well with the hypothesis of unit.characters and Mendelism, but W. L. Tower stated that he had been unable to make use of Mendel's ideas in his experiments, since in the offspring from his crossed forms the parental characters might or might not appear in the Mendelian ratios. C. B. Davenport voiced the widely entertained opinion that even in apparently contradictory cases, such as those presented by Tower, Mendelism gives a clue that will aid in unravelling the tangle of factors.

Good contributions to systematic zoology and geographical distribution were not lacking. C. Hart Merriam gave an account of the

work of the U. S. Biological Survey. There were papers on cestodes by Edwin Linton, on bryozoa by R. C. Osburn, on isopods by Miss Harriet Richardson. The evolution of species and races in certain land shells of the Society Islands was discussed by H. E. Crampton who has made a careful study, during several visits to the islands, of the local distribution of the different forms.

Mention should be made of a number of papers by H. S. Jennings, L. L. Woodruff, and others on the behavior of protozoa in respect to conjugation and in response to various stimuli. The instinctive actions of higher forms, too, received attention, especially in one of F. H. Herrick's studies of bird behavior (cuckoo) in G. A. Drew's account of the reproductive processes of the squid. Finally there were papers dealing with the analysis of physiological processes in the adult. Among these may be mentioned A. G. Mayer's fine study of the cause of rhythmical pulsation in the scyphomedusae.

H. V. WILSON.

CHEMISTRY

The 39th general meeting of the American Chemical Society was held in Baltimore Tuesday, December 29, 1908 to Friday January 1, 1909 in conjunction with the meeting of the American Association for the Advancement of Science. The attendance was the largest in the history of the society, partly due to the favorable meeting place and partly due to the fact that recent large accessions to the membership have made it one of the largest chemical societies in the world. The last report gave an enrollment of 4008. The great increase in membership during the last year was primarily due to the establishment of the Industrial Division and the promise of a journal devoted to technical chemistry. This "Journal of Industrial and Engineering Chemistry" has now made its appearance. Two years ago the society began the publication of "Chemical Abstracts", a semi-monthly periodical, the most complete chemical abstract journal published. Three journals are now issued by the society. The success of the Industrial Division led to the organization at Baltimore of the Division of Physical and Inorganic Chemistry, Division of Organic Chemistry and the Division of Fertilizer Chemistry.

By far the larger part of the papers are given in sectional meetings but at Baltimore more than the usual number of general meetings was held, thus bringing all sorts of chemists together more than ordinarily. This general mixing was further increased by the fact that the best place to obtain the noon lunches was at the Woman's College where the meetings were held. In the morning of the first day the society listened to the following addresses: "The Untilled Field of Chemistry" by A. D. Little, Chairman Division Industrial Chemists and Chemical Engineers, "The Use and Abuse of the Ionic Theory" by G. N. Lewis, Chairman of Physical Chemistry Section; "The Work of Werner on the Constitution of Inorganic Compounds" by Charles H. Herty, Chairman of Inorganic Chemistry Section. The afternoon was given exclusively to the meeting of the new Section of Chemical Education, four papers being presented as follows: "Science Teaching as a Career" by H. P. Talbot, Chairman of this section; "The Efficiency and Deficiencies of the College Trained Chemist when Tested in the Technical Field" by William H. Nichols; "To What Extent Should College Training Confer Practical Efficiency along Technical Lines" by L. M. Dennis; "The Attitude of Technical Institutions to Post Graduate Study" by William McMurtrie.

In the evening at the Hotel Belvedere William Simon gave an illustrated lecture on the "Lumiere Process of Color Phography." This was followed by a complimentary smoker. Sectional meetings were held Wednesday forenoon and on subsequent days. Agricultural and Food Chemistry Section, H.J. Wheeler, Chairman, 21 papers; Biological Chemistry Section, J. J. Abel, Chairman, 16 papers; Division of Industrial Chemists and Chemical Engineers, A. D. Little, Chairman, 26 papers; Fertilizer Chemistry Section, F. B. Carpenter, Chairman, 10 papers; Pharmaceutical Chemistry Section, Edward Kremers, Chairman, 5 papers; Inorganic Chemistry Section, Charles H. Herty, Chairman, 17 papers; Organic Chemistry Section, S. F. Acree, Chairman, 29 papers: Physical Chemistry Section, Gilbert N. Lewis, Chairman, 31 papers. Wednesday afternoon was devoted to two excursions, one to the U. S. Naval Academy at Annapolis and the other to Sharp and Dohme, pharmaceutical chemists. In the evening at the Girl's

Latin School Prof. M. T. Bogert, President of the Society delivered an address on "The Function of Chemistry in the Conservation of Our Natural Resources." It was shown that chemistry does play and will play a more important role in the conservation of our resourses by developing better methods of working up the natural resources and new methods of utilizing waste products.

Thursday forenoon at the business meeting resolutions of respect on the death of Wolcott Gibbs were passed. The following addresses were given at this time: "The Future of Agricultural Chemistry" by H. J. Wheeler, "The Quantitative Study of Organic Reactions" by S. F. Acree, "The Classification of Carbon Compounds" by Edward Kremers. In the evening a subscription dinner was given at the Hotel Belvedere. It was an unusual success, not only in point of cuisine but in the great enthusiasm and jollity that was manifest throughout the evening. On Friday adjourned meetings of the sections were held and a trip was made to the Maryland Steel Company's works at Sparrow's Point. William R. Whitney, Director of the Research Laboratories of the General Electric Co. was elected president for the coming year. The following were elected Councilors-at-Large: W. Lash Miller, Chas. H. Herty, S. W. Parr, W. H. Walker. The summer meeting of 1909 will be held at Detroit and the winter meeting at Boston. ALVIN S. WHEELER.

PHYSICS

The attendance at the meetings of Section B was larger than ever before, the Physics lecture room at the Johns Hopkins University being comfortably filled at almost every session. No striking discoveries were reported, and there was not the enthusiasm which greeted for example, the papers of Rutherford at earlier meetings, but the interest was sustained throughout, and the discussions were incisive and entertaining. The noticeable feature was that while all the speakers seemed to realize that the electron theory is yet simply a working hypothesis, still the language and the conceptions of that theory were constantly used to explain phenomena described in various papers. The listener could not fail to discern a quiet note of confidence in the substantial accur-

acy of that theory. Another point of interest was that terrestial and cosmical physics was brought into prominence as never before at these meetings. Quite a number of papers were presented dealing with various phases of this growing branch of physical science, and Dr. L. A. Bauer, Director of the Department of Terrestial Magnetism of the Carnegie Institution, took a prominent part in the discussions, and indeed was elected Vice-President of Section B for next year. Many papers dealt with attempts to "try out" many phases of the Electron Theory experimentally, in some cases w!th negative, in other cases with positive results. Among the more inportant papers should be mentioned those on "The extension of the Balmer series of lines in the Sodium Spectrum," by Prof. R. W. Wood, of Johns Hopkins University; "The Optical Properties of Films of Magnetic Metals," by Prof. C. A. Skinner, University of Nebraska; and "Solar Vortices and Magnetic Fields," by Prof G. E. Hale, of Mount Wilson Observatory, Cal.

The Physicists' Dinner, a new departure, at the Country Club near Baltimore, was a decided success, and will doubtless be a regular part of the program in the future. It was decided at this dinner to cable the congratulations of those present to Prof. Ernest Rutherford, a former member of the American Physical Society, on receiving the Nobel prize in Chemistry for last year.

A. H. PATTERSON.

GEOLOGY

The twenty-first annual meeting of the Geological Society of America was held in the geological building of Johns Hopkins University, Tuesday to Thursday, 29 to 31 December, 1908. The morning and afternoon sessions were devoted to the transaction of business and the reading and discussion of original papers. The formal address by President Samuel Calvin on "The Latest Phase of the Pleistocene Problem in Iowa" was delivered Tuesday enening in the main lecture room, followed by a smoker and social hour in the laboratory. Wednesday evening the annual dinner of the Society took place at the Hotel Rennert, President Calvin acted as toastmaster. Over one hundred geologists were present. The guest of honor was Professor Albrecht Penck, of the University of Berlin. Informal talks were make by Professor

Penck, Professor Chamberlain, President Van Hise, Professor Stevenson, Professor Fairchild, Dr. W. B. Clark, and others. Dr. Gilbert spoke feelingly of his life spent in geology. Dr. G. O. Smith told of the work of the federal survey, and Dr. Brock spoke in behalf of the Canadian Survey.

Seventy two papers were listed on the programme, of which about three-fourths were read. They were arranged in the following groups: Physical and Structual, Glacial, Stratigraphic, Areal, Paleontologic, Petrologic, Physiographic, Cartographic, Economic. By invitation of the council Professor Penck delivered a lecture on interglacial epochs Wednesday morning. This great geograper and glacial geologist in the brief time at his disposal summed up the evidence, as exhibited in the Alps and in North America, bearing upon the lapses of time between the different ice invasions.

"Some Distinctions between Marine and Terrestial Conglomerates", by Joseph Barrell, followed the same line which this author has pursued for some years, and showed his usual painstaking research. Professor Chamberlain's paper, "Diastrophism of the Ultimate Basis of Correlation", was appreciated by all. The sensation of the meeting came when Frank B. Taylor in his paper, "The Bearing of the Tertiary Mountain Belt upon the Origin of the Earth's Plan", suggested the possibility of the earth having captured the moon in late geological time, thus accounting for the earth's polar shortening. The papers by Fairchild on the recession of the ice in New York, elicited much comment from Brigham and others, and it seemed difficult for the glaciologist to agree upon details. Dr. W. B. Clark spoke of the results of the invistigation of the coastal plain formations along the Atlantic coast. Of interest to North Carolinians were the papers by E. W. Berry on "The Geologic Relations of the Cretaceous Floras of Virginia and North Carolina", and by S. L. Miller on "Erosion Intervals in the Tertiary of North Carolina and Their Bearing upon the Distribution of the Formations". Dr. E. O. Hovey displayed some very fine views of Mont Pelé and the Soufrière taken last summer, and pointed out recent changes in the two volcanoes.

The paper most eagerly awaited by stratigraphers and general geologists entitled, "Revision of the Paleozoic Systems in North

America'', by E. O. Ulrich was read to a crowded audience. Dr. Ulrich has spent many years during his connection with the U. S. Geological Survey in gathering first hand knowledge of the Paleozoic formations, and his conclusions are the ripe fruit of a mind long trained in field observation and paleontology. Such vague terms as Cambro-Ordovician and Devono-Mississippian are decried by him as savoring of ignorance, and the attempt is made to show that defiinite boundaries can be discovered by careful field search and close correlation. "The proposed classification is based primarily on crustal movements, diastrophism, the succession of which is determined by the faunal evidence. The occurance of such movements is determined, aside from plain physical evidence, primarily by mutations in the faunas, especially by the introduction of new faunal elements and facies, etc.'' One of the proposed changes is the insertion of a new system, the Ozarkian, so-called for its development in Missouri and Arkansas, between the Cambrian and Ordovician systems. This system occurs also along the Appalachian Valley from New York to Alabama, and is separated from both Cambrian and Ordovician by unconformities. Another change consists in placing the Meramec and Chester groups of the Mississippian in the system, the Tennesseean, between the Mississippian and the Pennsylvanian.

The meeting of the Society disbanded with the offering of a formal vote of thanks to Dr. W. B. Clark and his colleagues for the entertainment and courtesy extended to all visiting geologists.

H. N. EATON.

BOTANY

The recent meetings in Baltimore of the botanists of America were the largest, most interesting, and most successfully conducted of any ever held in this country. The botanical societies that came together there were Section G. of the American Association for the Advancement of Science, The Botanical Society of America, The Sullivant Moss Society, The Wild Flower Preservation Society, and The American Nature Study Society (which is interested in the teaching of botany).

The Secretaries of Section G. and of the Botanical Society of

America were so successful in arranging their sessions as to avoid any conflict of programs, but it was found necessary to segregate the papers on fungi into a separate program. This withdrawal of the fungologists into sessions of their own marks another step in the process of specialization that characterizes the advance of all our sciences. The economic importance of the fungi in producing diseases of plants and animals has naturally attracted much attention to them, and papers on their structure and habits are becoming more numerous with each succeeding year.

Attractive as the newer fields of botanical research undoubtedly are, they have not led to a decline of interest in the subjects of morphology and classification. Such papers as Chrysler's "On the nature of the fertile spike in the Ophioglossaceae" which throw new light on relationships, and as Shattuck's on the "Origin of Heterospory in Marsilea", a good piece of work on experimental morphology, never fail to attract attention.

During the last few years the most notable development in our knowledge of morphology has been along the line of vascular anatomy. In the words of Prof. John M. Coulter "Phylogenetic vascular anatomy was developed at an auspicious time, for phylogeny based upon reproductive structures was beginning to waver. Wider research had begun to dissipate rigid categories into mists, and especially had expermental morphology begun to play havoc. The whole situation has been steadied, at least momentarily, by the recent development of vascular anatomy, including as it does the enormously important ancient history of the vascular groups."

Prof. J. C. BOSE, a hindoo, who was here on a commission from the government of India, gave an address on the little known subject of "Electrical response in plants" that attracted much attention.

From the program it was obvious that the study of ecology* is gaining ground. A symposium on the subject was held by the Botanical Society of America in which papers were given by

---

*Students of Dr. W. K. Brooks will remember how much he disliked that word, claiming that it was not needed, its meaning being entirely covered by the word "biology".

Cowles, Livingston, Shaw Spalding, and Transeau. Expressions in these papers indicated that the long dominent idea that all structure and activities of a plant must have some useful purpose or express some adaptation is fast being replaced by one that admits the possibility of useless structures. It is a relief, as Cowles says, not to be compelled to find adaptations where none exists.

Interest in the factors of evolution and the laws of inheritance is still most active, and evidence is being sought by experiments in many directions. The mutation theory and the laws of Mendel still focus the attention of the students of evolution; but it seems evident that we are still far from the time when these highly complex phenomena may be expressed in simple laws.

To commemorate the birth of Charles Darwin one hnndred years ago a memorial session was held by the Botanical Society of America. The following addresses were made:

"General sketch and estimate of Darwin's work on cross-pollination in plants," by William Trelease. "Estimate of Darwin's work on movement of plants," by H. M. Richards. "Darwin's influence on plant ecology and plant geography," by F. E. Clements. A Darwin centenary memorial was also held by the American Association for the Advancement of Science, together with the American Society of Naturalists, all sciences participating. The two addresses given by botanists were as follows: "The Theory of Natural Selection from the standpoint of botany," by John. M. Coulter; "The Direct Effect of Environment," by Daniel T. MacDougal. From the tenor of these addresses it was evident that the fame of Darwin is in no wise on the decline. His influence on science, philosophy, life is beyond all estimate. Fifty years have passed since the publication of "The Origin of Species," years unparalled for progress in the history of the world; and it was the momentum of Darwin's thought that initiated that progress and that sustained it in its course. Since that eventful year of 1859 much new knowledge has been acquired and points of view have changed, new theories have been proposed and old ones modified; but through bitter assault and turmoil and testing the foundations that Darwin built

have remained unshaken, and of all the great names that make memorable the 19th century his, at least, is secure:

> "Nothing is here for tears, nothing to wail
> Or knock the breast; no weakness, no contempt,
> Dispraise, or blame; nothing but well and fair,
> And what may quiet us in a" life "so noble."

W. C. COKER.

PLATE I.

Fig 1

Fig. 3

Fig. 2

Fig. 4

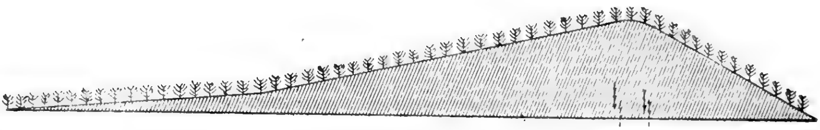


Fig. 5

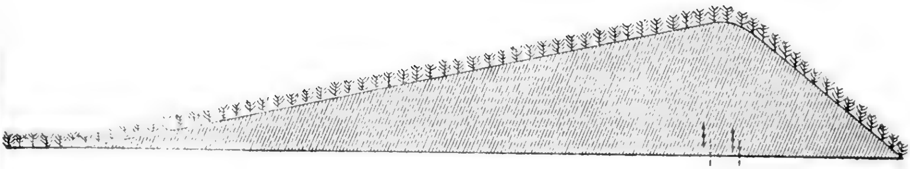


Fig. 6.

DIAGRAMS EXPLAINING PROGRESSIVE STEPS IN THE FORMATION OF BARRIER DUNE

When the dune has assumed the form illustrated by Fig. 4, grass is planted, and by extending the area planted towards the shore (to the left) the subsequent form of the dune is influenced.

North Carolina Geological Survey.